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# Research & Development Opportunities for Advancing Highway Freight Transport Technologies

by

Transportation Development Centre
Policy and Coordination Group
Transport Canada

Montreal, Quebec
March 1989

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# RESEARCH & DEVELOPMENT OPPORTUNITIES FOR ADVANCING HIGHWAY FREIGHT TRANSPORT TECHNOLOGIES

by

Sesto Vespa and Phillip Toogood

TRANSPORTATION DEVELOPMENT CENTRE
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16. Abstract

Current technological issues in highway freight transport are examined with reference to the current state of the industry. Research areas are identified that cover the range of technologies spanning vehicle, driver, infrastructure, operations, compliance with regulations, and collection of exposure and accident data. Technology assessment and diffusion are discussed with a view to the needs of government and industry.

Research and development in highway freight transport technologies is also presented in the context of federal government and Transport Canada objectives, priorities and responsibilities. From this perspective, objectives and sub-objectives for an R&D program to be conducted by the Transportation Development Centre are proposed that respond to the federal government mandate and to industry needs.

Information was gathered through a literature survey and from interviews with, and written comments from, representatives of several federal government departments and six provincial governments, various manufacturers, operators and industry associations, and researchers in federal, provincial and university laboratories.

One purpose of the study was to provide a précis of current thinking on R&D areas of opportunity, to help promote expansion of related activities and to encourage cooperation among Canadian researchers within, and between, the public and private sectors.

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16. Résumé

Ce rapport examine les questions du transport routier de marchandises sous l'angle technologique et dans la conjoncture actuelle. Il identifie des créneaux de recherche couvrant toute la gamme des technologies intéressant les véhicules, le conducteur, l'infrastructure routière, l'exploitation, la conformité à la réglementation et la saisie de données sur les accidents et l'exposition aux risques d'accident. L'aspect évaluation et diffusion technologiques est traité sous l'angle des besoins des secteurs public et privé.

Les créneaux de recherche et de développement dans le domaine du transport routier de marchandises sont présentés également dans le contexte des objectifs, des priorités et des responsabilités du gouvernement fédéral et de Transports Canada ainsi que des besoins du secteur privé. Dans cette double perspective, le rapport propose un programme de R&D pouvant être pris en charge par le Centre de développement des transports, dont il expose l'objectif général et les sous-objectifs.

Ce rapport s'alimente d'informations tirées de recherches documentaires, d'interviews personnelles auprès de hauts fonctionnaires dans plusieurs ministères fédéraux et six gouvernements provinciaux, ou bien de mémoires émanant de ces derniers, mais aussi d'équipementiers, de transporteurs routiers, d'associations professionnelles et de chercheurs aux niveaux fédéral, provincial et universitaire.

L'objectif principal de l'étude a été d'aider le CDT dans la planification et la réalisation d'actions de R&D finalisées portant sur les technologies de transport routier de marchandises.

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# An Invitation to the Canadian Transportation Community

There is no single agency responsible for all facets of highway freight transportation in Canada. As a result, it is difficult to consider highway transportation from a system perspective, an approach essential for optimizing service design and operation. In order to make fundamental progress, it will be necessary for all levels of government and industry to adopt a cooperative approach. This is especially true in 1989, when we stand on the threshold of a revolution in highway transportation. In the not-too-distant future, computers, communications and other electronic systems may generate an "electronic highway" that inseparably links driver, vehicle and roadway through a vastly distributed network that provides selectable control, guidance, and advisory functions. Isolated and unco-ordinated approaches to research and to implementing its results will become increasingly less fruitful as the responsibilities of the various governments and industry become increasingly linked.

Highway freight transport technology is of growing importance to Transport Canada and is the subject of increased research and development (R&D) activity by the Transportation Development Centre. Highway freight transport has a major influence on consumer costs and on the competitiveness of the nation's exported products. Government and industry must address the increasing social concerns about the safety impacts of larger and heavier vehicles occupying even more of the nation's road infrastructure. There is also increasing recognition of the large potential that highway freight transport has for providing new technological products and services as well as for creating additional jobs.

This report presents a compendium of potential R&D activity areas and projects for advancing highway freight transport technologies. It provides a précis of current thinking on R&D areas of opportunity to help promote expansion of related activities and to encourage cooperation among Canadian researchers.

Economic regulatory reform has created an environment that fosters and rewards competitive advantage now more than ever before. Innovation, fundamental to maintaining long-term advantage, requires a sustained long-term commitment to research and development. Transport Canada has decided to make this commitment and invites the transportation community at large to do likewise, both by giving a higher priority to research and development and by making the resources available to support it.

R.R. Mayes

R.R. Mayes
Director General
Research and Development

Canada

# SUMMARY

## BACKGROUND

Transport Canada's Transportation Development Centre (TDC) has slated highway freight transport technology as an area for increased research and development (R&D) activity and will allocate additional resources to it. This is in response to the increasing role of highway freight transport in Canada's economy and the public's increasing awareness of its potential effects on highway transportation overall.

### OBJECTIVES

This report presents the results of a study, which TDC decided to undertake in April 1988, with the following objectives:

1. To provide a précis of current thinking on R&D areas of opportunity, to help promote expansion of related activities and to encourage cooperation among Canadian researchers within, and between, the public and private sectors.
2. To provide the private sector and all levels of government with an understanding of the R&D objectives of Transport Canada, and the associated context within which Transport Canada's central R&D activities are developed and conducted.
3. To assist TDC to plan and execute focused R&D activities relating to highway freight transport technology.
4. To facilitate coordination of TDC's R&D program with that of other organizations that are involved with highway freight transport R&D.

### SCOPE

This report addresses highway freight transport that generally covers commercial vehicles operated by private, for-hire, and household-goods movers, normally operated at gross vehicle weights in excess of 5 500 kg.

### METHODOLOGY

The report was developed in-house from information gathered through a literature survey and from interviews with, and written comments solicited from, experts covering a wide spectrum of the industry. These included representatives of several federal departments, six provincial governments and various manufacturers, operators, industry associations and researchers in federal, provincial and university laboratories.

## RESEARCH AND DEVELOPMENT IN THE FEDERAL GOVERNMENT

Transport Canada's central R&D activities are administered by the Research and Development Directorate. This directorate has appointed TDC as the program delivery organization. TDC's program is wide in scope and covers all modes. It is intended to complement and extend beyond, but not replace, R&D initiatives being undertaken by Transport Canada's operating groups and required to support their operational, regulatory and procurement needs. The department responsible for road safety and motor vehicle regulation, for example, conducts its own R&D program to address specific regulatory and road safety initiatives. TDC's program is almost entirely contracted out to the private sector.

TDC's R&D program must respond to federal government objectives and priorities, as well as to those set by various Transport Canada components. For purposes of this report, these are summarized in Table A based on consideration of Transport Canada's 1988 Corporate Priorities. These are under revision but current concerns, from an overall perspective, continue to deal with safety and efficiency, security, transport of dangerous goods, environment, and regional development.

### TABLE A

### FEDERAL GOVERNMENT AND TRANSPORT CANADA DEPARTMENTAL OBJECTIVES AND PRIORITIES

1. Improve transportation safety and security including improved measures for the transportation of dangerous goods.
2. Stimulate and support national and regional economic development.
3. Promote improved efficiency and productivity.
4. Reduce energy requirements and promote efficient utilization of national resources.
5. Undertake and stimulate effective R&D.
6. Stimulate international trade.
7. Develop alternative investment strategies.
8. Preserve useful national infrastructure investment.

TDC's R&D activities fall into the following three categories: exploratory, long-term or sector-directed. The purpose of exploratory R&D is to produce knowledge through wide-ranging, systematic assessments of new developments; long-term, to support departmental or previously defined group objectives; and sector-directed, to support innovation in the transport sector and hence further departmental objectives and priorities.

## TRANSPORT INDUSTRY STATISTICS

In 1986, the Canadian trucking industry incurred operating expenses of $12.3 billion. In comparison, the gross operating expenses for all railways, including VIA Rail, were $6.95 billion (1984) and those of the domestic airlines were $5.4 billion (1985). In the public sector, the federal, provincial, and municipal governments spent a combined $4.7 billion (1986) on highway construction and maintenance. In regards to trade with the United States, the primary method of transport is by truck, accounting for 59% of exported goods and 72% of imports. Using operating expenses to measure truck transport activity, for-hire and private carriers (with some minor differences) domiciled in Ontario accounted for 40% of total Canadian expenses; Quebec for 18%; Alberta for 13%; British Columbia for 11%; Manitoba and Saskatchewan for 12%; and the Atlantic provinces for 6%.

The majority of private trucking firms are local carriers, with more than 89% of their power-unit fleets made up of straight trucks. For-hire carriers are mainly involved in intercity transport, and more than 65% of their power fleet is made up of road tractors. Provincial registration fleet statistics show that in 1986, British Columbia had the oldest fleet, with 75% of its trucks being 6 years old or more. Ontario and Quebec have the heaviest fleets, with 20% of vehicles having a gross vehicle weight designation of 45 360 kg (100 000 lb) or more.

## HIGHWAY FREIGHT TRANSPORTATION RESEARCH AND DEVELOPMENT

In order to develop an effective R&D program for the area of highway freight transportation, the shared roles of the federal and provincial governments in this area must be understood.

### THE FEDERAL GOVERNMENT'S ROLE

Table B details federal government legislation dealing with highway transportation. These acts define limits of authority, standards of performance and requirements to be met for commercial activity, technological products and operations. Table C lists the main responsibilities the federal government has acquired in this area.

TABLE B

**FEDERAL GOVERNMENT LEGISLATION DEALING WITH HIGHWAY TRANSPORTATION**

1. Department of Transport Act.
2. National Transportation Act.
3. Motor Vehicle Transport Act.
4. Motor Vehicle Safety Act.
5. Motor Vehicle Tire Safety Act.
6. Transportation of Dangerous Goods Act.
7. Motor Vehicle Fuel Consumption Standards Act.

The federal government's direct effects on highway transportation are a result of legislation specifically addressing this area of transportation (from Table B), other legislation that has a direct impact on highway transportation (e.g., the Railway Safety Act for railway level crossings) and federal-provincial agreements for assistance to specific transportation projects.

The federal government indirectly affects highway transportation when highway transportation plays an important role in determining the success of federal policies and initiatives in other unrelated areas. For example, highway transportation is vital for trade and tourism and will play a pivotal role in the success of Canadian industry under free trade. Strategic planning and use of the highway system are critical to successful military operations as well as for emergency planning and response.

Highway transportation is also affected indirectly by the federal government through administrative decisions, such as participation in cooperative arrangements with the provinces to promote national highway transportation objectives. Two such examples are federal participation in the Council of Ministers of Transportation and Highway Safety and the Canadian Council of Motor Transport Administrators.

TABLE C

**THE FEDERAL GOVERNMENT'S ROLE IN HIGHWAY TRANSPORTATION**

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**DIRECT**

1. Vehicle safety regulation.
   a. Regulation of new vehicles and tire design and manufacture.
   b. Requirements for correction of safety defects.
2. Regulation of transportation of dangerous goods.
3. Regulation of extraprovincial motor carrier transport.
4. R&D in support of Transport Canada's mandate in highway transportation.
5. Highway/railway safety and level crossing protection program.
6. Highway safety educational programs.
7. Construction and maintenance of roads on federal property.
8. Federal support to provinces for specific road construction projects.
9. Federal support for road safety projects.
10. Bridges over navigable waters.
11. Highway motor vehicle and criminal code enforcement in several provinces.

**INDIRECT**

1. Free trade and international use of highway system.
2. Department of defense and strategic use of highway system.
3. Membership: Council of Ministers of Transportation and Highway Safety.
4. Membership: Canadian Council of Motor Transport Administrators.

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## PROBLEM AREAS AND POTENTIAL OPPORTUNITIES

In order to maximize the effectiveness of an R&D program addressing highway freight transportation technology, associated problem areas and potential opportunities must also be examined.

## Accident Data

According to statistics gathered by Transport Canada's road safety branch, 400 to 460 deaths occurred each year between 1984 and 1986 as a result of accidents involving heavy commercial vehicles. An additional 9 000 to 9 700 personal injuries are also attributed to accidents involving heavy trucks between 1984 and 1986.

The fundamental problem faced when trying to improve upon these statistics is deciding where limited resources could be best allocated to achieve the best results. This is very difficult since accidents are generally the result of many contributing and interrelated factors. A comprehensive and consistent data base detailing accident and exposure data is vital to identification and assessment of countermeasures.

All Canadian jurisdictions require that vehicular accidents involving injury or death be reported, as well as those involving property damage above specified monetary levels. They do, however, differ on the following three salient points: the time frame following an accident during which a death may be attributed to the accident, the definitions, and the level of property damage required for reporting.

In addition to the above differences, there are also jurisdictional differences in the requirement to record accident data. Although specific jurisdiction guidelines are provided detailing which accidents must be reported, guidelines regarding the completion of an accident report by a police officer are not clear and frequently vary within a jurisdiction due to the presence of different enforcement agencies (e.g. municipal, provincial and federal). In some cases, the accident form is completed by a person other than the attending police officer.

The accident report form has been designed to deal with passenger-car accidents, and typically includes data concerning vehicle identification, the vehicle occupants and their injuries, the location and time of the accident, the weather conditions and vehicle movement immediately prior to the accident. For commercial vehicle accidents, information relating to the vehicle configuration, its load and the driver's experience are not included. A combination vehicle, such as a tractor-semitrailer or a B-train, will frequently be identified solely by reference to the number plate or registration or licence of the power unit. Accident reports frequently do not identify trailers unless there is a specific reason to do so.

Because of the problems in assembling reliable accident data, Transport Canada has initiated a Traffic Accident Information Data (TRAID) system. It has also established 10 Multidisciplinary Accident Investigation (MDAI) teams at several universities across Canada. This accident data base should now be refined and expanded to provide for complete compatibility between provinces in order to serve in a national capacity.

## Exposure

In order to evaluate exposure correctly and accurately, it is necessary to be thorough and consistent in detailing the parameters that are to serve as measures of travel. This information is then linked to the accident counts for a given period. Vehicle configurations must be identified to obtain meaningful results that permit useful analysis and decision making. To this end, it is important to have classification equipment that is reliable, provides the minimum required data in a convenient format for easy handling and is low cost. Once this data is compiled, it must be effectively stored and analysed.

The basic requirements for setting up a "national sampling system" can be identified as follows.

1. A system of permanent counting stations (PCS) working 24 hours per day. The number and locations of PCS would be selected through analysis of the national road network. A representative cross-section of this network would be monitored as required by the data accuracy specification.

2. A proper sampling framework, established to permit the congruous operation of portable and permanent counting/ classification systems and to address impacts of seasonal changes, weather, changes in vehicle mix, etc. The portable units would permit adjustments to weighting factors used with the PCS, thereby leading to more accurate short-term results and following long-term trends more effectively.

A minimum of one or two provinces should be involved in setting up the national sampling system. The other provinces should then be incorporated as required.

In terms of exposure data, there are opportunities to be innovative in Canada. There has been rapid progress in data collection capabilities as a result of technological change. Many provinces (such as Quebec, Ontario and Saskatchewan) are looking at the possibility of expanding and updating their weigh station and traffic data systems. It is important that there be effective coordination of all efforts to facilitate further cooperation in the future and the implementation of a national sampling system. This system should reflect the country's present data-collection capabilities and the provinces' future plans. Its implementation will also likely involve negotiation with the provinces for specific requirements that go beyond provincial concerns.

Highway design and condition are two important factors that may contribute to accidents. To support the accident and exposure data-collection requirements, it is also essential to develop a national system aimed at identifying a position on the national highway system. The required precision would be prescribed by accident and exposure data needs.

### Technology Assessment and Diffusion

Canadian research into highway freight transport technologies is fragmented and often lacks international scope. Researchers have also had difficulty disseminating their findings to companies seeking solutions to existing and potential problems.

Nonetheless, Canadian researchers have made significant contributions to highway freight transport technologies. A means must be found to promote the work done by Canadian agencies within the global research community.

In order to be competitive, Canadian highway freight industries must incorporate the latest research technology in the most efficient and effective manner possible. Since a large proportion of highway technological advancements occur offshore, the identification and integration of valuable foreign technology is essential.

Technology transfer requires the adoption of a planned and structured approach by both industry and government. Government should promote a long-term view in industry by assessing national and international trends that have the potential for making significant impacts on the national economy and the international competitiveness of its industries.

Government and industry should promote cooperation of Canadian research and international technology exchange in areas that will have potentially beneficial results for the Canadian economy. In terms of emerging technologies, for example, it is important that robotics, computer and communications technologies be carefully examined from an international perspective for potentially important applications to traffic management (street control, freeway management, enforcement), vehicle monitoring and control, as well as for potential development toward the "electronic highway" that will ultimately link vehicle, driver and roadway.

These technologies have the potential to make revolutionary changes in technical capabilities and cost factors, thereby playing a key role in determining what transportation services are provided and how. Important efforts to provide high-technology products as a result of R&D advancements are now underway in Europe, the United States and Japan. Once they are established, these high-technology products will be sold worldwide. Canada must find its own way into these fields based on the transportation needs and technical capabilities of the national economy as well as through the manufacture of products for the local and export markets.

## Vehicle Technology

The transportation gross domestic product (GDP) for all transportation modes currently comprises 4.8% of the total Canadian GDP. This marks a significant improvement since 1961, when transportation GDP was 7% of the total; however, it is still almost 50% higher than the comparable figure for the United States. To remain competitive with American industries and to increase Canadian penetration of north-south freight traffic, further improvements in road transport productivity must be achieved. The two areas in which improvements can be foreseen is in regulatory uniformity and transportation electronics.

Notwithstanding the productivity gains, the area of truck electronics will play a major role in advancing commercial vehicle safety. Based on available registration and accident data, heavy commercial vehicles are involved in about 3.5% of all reportable accidents and 10% of all road fatalities. Not only is the public concerned over the disproportionate involvement of trucks in fatal accidents, but it is also concerned that in those accidents, an occupant of the other vehicle, usually a passenger car, is usually the fatally injured party. Equally alarming to commercial vehicle operators are United States and European studies that rate the trucking industry as having an annual fatality rate of 58 deaths per 100 000 workers, second only to mining and quarrying at 60 deaths per 100 000 workers. The average industry experiences 11 deaths per 100 000 workers.

Truck safety electronic systems of the future will monitor and record: driver medical and physical condition, providing a feedback alarm for specified unsafe conditions; vehicle dynamic performance, providing the driver with warnings of potentially unsafe conditions; and condition of safety-related components and scheduling of maintenance and repair work. They will control the operation of drivetrain, suspension and brake components to optimize performance, preselect routes based on traffic volumes and monitor loading practices.

Commercial vehicle safety issues fall into a wide range of classifications including vehicle stability, dynamic response, aggressiveness, crashworthiness, braking, ergonomics, visibility, maintenance and reliability. In turn, each of these classifications contains multiple subclassifications.

Opportunities for R&D in vehicle technology, identified in general areas, are as follows:

1. Design features for improved vehicle safety, such as for reduced aggressiveness, improved crashworthiness and occupant protection, maximized braking efficiency and effectiveness, and optimized ergonomics for better driver control and traffic interfacing.

2. Improved combination vehicle dynamics through application of weight and dimension design criteria to trucks and trailers, development of stability and control performance criteria for trailer and semitrailer coupling devices, use of semi-active and active trailer axle steering mechanisms, development of effective anti-jackknife devices, enhancement of engineering tools for analysis of combination vehicle dynamics and improvement of tank design for reduced slosh.

3. Improved suspension dynamics through development of internationally recognized test methodology, understanding the influence of mixed suspension parameters on vehicle control and stability and development and use of high-stability suspension systems.

4. Better understanding of the overall effect of combination vehicles on the roadway-suspension interface.

5. Improved energy and environmental conservation and fuels substitution through technologies for engine and drivetrain tribology, energy efficiency, use of alternative fuels, assessment of fuels and fuel additives, minimized aerodynamic drag and reduced exhaust emissions.
6. Improved on-board electronic systems.
7. Feasibility study of an advanced concept vehicle (with broad participation of Canadian research community) that incorporates, to the greatest extent possible, the latest technology in each design area.
8. Enhanced productivity of special-purpose vehicles (auto carriers, furniture vans and household goods movers, logging industry vehicles, extended vehicle combinations and cargo containers that can be used for more than one transportation mode) through improved vehicle design and operation.

### Infrastructure Technology

Current federal expenditures for road infrastructure maintenance and construction amount to $225 million per year. Under agreements already in place, the federal government will spend $1.233 billion over the next 15 years in contributions to the provinces for road construction. This makes the federal government one of the largest sources of highway funds in Canada, exceeding the annual highway budgets of six of the ten provinces. It would therefore be prudent for Transport Canada to establish both safety and maintenance criteria within its procurement and contribution objectives, in order to minimize its long-term contributions, and to ensure that technical innovations in highway construction and maintenance techniques are adopted.

In the area of infrastructure technology, it is essential that research and development be conducted in cooperation with the provinces. The American Strategic Highway Research Program (SHRP) and the Canadian Strategic Highway Research Program (C-SHRP), to which Transport Canada currently contributes, focus on the rehabilitation and maintenance of existing highways. The programs, however, do not address the relationship between design standards and road safety, nor do they focus on the interactions between vehicle vertical dynamics and pavement and bridge damage.

The following potential R&D opportunities have been identified in broad areas that deal with the impacts of vehicle-to-infrastructure, infrastructure-to-vehicle and roadway design.

1. Understanding the dynamics of vehicle loads and suspensions, and their interaction with the pavement, for improved vehicle design.
2. Development of technology to minimize vehicle contribution to road wear, to minimize government and industry costs.
3. Development of alternative materials for pavements and structures for improved energy efficiency, materials substitution and reduced corrosion and environmental deterioration.
4. Updating of highway geometric and signage standards for compatibility with the dynamic performance of the new generation of Canadian heavy commercial vehicles, and to provide for changeable message signs.
5. Support of C-SHRP and SHRP projects for improved design, construction, maintenance and long-term performance of highway infrastructure.
6. Federal support for the establishment of a national standard for locating accident sites, and support for implementation of the standard through required conformance in federally financed projects.

7. Investigation of pavement surfacing techniques to reduce wheel splash and spray without detriment to other desirable pavement requirements.
8. Updating of roadside furniture standards for compatibility with today's lightweight front-wheel drive passenger vehicles and the new generation of heavy commercial vehicles.
9. Development of a highway safety furniture maintenance handbook to be followed on all highways supported through federal funds.

### Compliance Technology

The provincial and territorial governments operate approximately 150 permanent, 150 portable and 50 weigh-in-motion (WIM) weigh scales, with about 900 staff and a combined annual budget approaching $300 million. Weigh scales staff in the majority of jurisdictions do more than just weigh trucks. Many facilities monitor vehicle licences and registration, vehicle insurance, motor fuel and sales taxes, motor-carrier authority, driver licencing, inspection certificates, mechanical condition, dangerous goods placarding, driver training cards, special operating permits and vehicle dimensions. With the introduction of the National Safety Code, these facilities will also soon be monitoring hours of service.

Most violations of provincial regulations result in civil charges against either the vehicle owner, the operator or the driver. Because many of the charges are challenged through the courts, the weighmaster must be prepared to present sufficient evidence of the violation to a court of law. The specifics determining each offence vary from province to province, depending upon the wording of statutes, thus making a nationally accepted prosecution or defence very difficult. However, there are opportunities to use technology to improve the accuracy and productivity of techniques that monitor compliance with national regulations, as follows.

1. Development of a national standard for static axle scales, on-board weigh scales and weigh-in-motion scales.
2. Development and demonstration of a system for integrating automatic vehicle identification and provincial records, thereby bringing violations to the attention of the weighmaster.
3. Development of improved on-board weigh scales, allowing the vehicle operators to maximize payload while remaining within legal limits.
4. Improvement of weigh-in-motion scale technology to lower costs and to improve accuracy and reliability at higher speeds in order to reduce traffic delays, and expand automation features to reduce staffing costs.

### Operational Technology

Operational technology spans a whole range of issues dealing with driver performance as well as vehicle and fleet operations.

Traffic safety experts generally agree that approximately 70 to 80% of vehicle accidents are attributable to driver error. Attempts are now being made worldwide to address the causes in a more systematic manner.

In Canada, the National Safety Code for Motor Carriers specifically addresses commercial vehicle driver licence classifications, training and examination; violation records and interjurisdiction records exchange, and drivers' hours of service. Specific human factors relating to vehicle safety still require further attention.

In terms of vehicle and fleet operations, major advances are foreseen in areas relating to vehicle dispatching and vehicle location identification. Active vehicle location technology has not yet been sufficiently integrated into commercial transport fleets to allow automated route calculation, with instructions conveyed automatically to the driver en route. En-route instruction currently requires a voice communications link between driver and dispatcher in order for the dispatcher to know the location of the vehicle. If a passive link between the vehicle and a dispatch computer could establish the location of each vehicle, an expert system could calculate en-route changes so as to maximize fleet efficiency. Similarly, passive vehicle location technology can be used to trace en-route cargo, which is becoming more necessary with just-in-time manufacturing techniques. Passive vehicle location technology can have other applications, particularly with respect to highway planning, dangerous goods routing, emergency response vehicle security and driver route guidance.

The following potential areas of opportunity for operational technology R&D have been identified.

1. Understanding driver behaviour and limits of performance, including driver reactions to external perceptions and stimuli, as well as the effects on the driver when distractions such as cellular telephones, video screens and route guidance systems are introduced into the driver area.
2. Improvement of ergonomics and human factors engineering to reduce driver fatigue and increase driver awareness of events occurring around the vehicle.
3. Development of technologies that aid driver training, evaluation and licensing, and that promote uniform minimum qualifications for operators under the National Safety Code.
4. Development of driver monitoring systems for medical and physical conditions, including hours of service, that provide feedback on the driver's condition and are aimed at improving driver decisions.
5. Development of driving aids that improve vehicle control and provide advance warning of potentially hazardous conditions such as a shift in trailer centre of gravity, trailer swing or impending vehicle upset.
6. Enhancement of dangerous goods transportation safety, including non-destructive testing techniques for materials, more effective hazard containment technologies, improved communications systems, more secure product identification and expanded applications of expert systems for rapid emergency response.
7. Examination of communication and computer technologies in support of fleet and traffic management, mobile office and travel advisory functions, and to optimize use of the highway system around principal transportation hubs.

## PROPOSED TDC R&D PROGRAM IN HIGHWAY FREIGHT TRANSPORT TECHNOLOGIES

In developing a proposal for TDC's R&D program for highway freight transport technologies, it was necessary to consider the perceived opportunities for R&D in the context of federal government and Transport Canada priorities, as well as the R&D mandate given to TDC. It was also necessary to consider federal responsibilities in highway transportation. From these considerations, and after a great deal of consultation with provincial and federal governments, industry and industry associations, the overall objective of TDC's highway freight transport technologies R&D program was proposed as follows:

> "To undertake and promote cooperative research, development and demonstrations relating to the safety, productivity and operation of commercial vehicles, their effects on roadways, the transportation of dangerous goods, energy efficiency, and alternative fuels."

Concurrent sub-objectives were also proposed for this program, as follows.

1. To develop data-gathering technology and systems to support the corporate need for meaningful heavy truck exposure and accident data.
2. To facilitate the systematic assessment and diffusion of new developments in highway freight transport technology.
3. To advance research into highway freight transport technologies relating to vehicle safety and productivity.
4. To advance research into the interaction between highway freight vehicles and roadways and its effects on vehicle design.
5. To stimulate applications of technology and enhancement of existing technology to improve the performance and productivity of compliance techniques that support national regulations.
6. To investigate advanced technologies for improved operations in the highway transport sector, and related human factors, to assist Canadian transportation industries in operating more safely and efficiently and in keeping pace with emerging technologies.

## CONCLUSION

There are many and varied R&D opportunities available for advancing highway freight transport. These touch upon virtually every facet of the industry and will ultimately determine its economic position vis-à-vis the competing modes as well as the public's acceptance of an increasing role for the industry on the nation's road network.

With the limited funds available to the Transportation Development Centre to address highway freight transport R&D, its emphasis will be upon those areas that support Transport Canada's mandate in highway transportation. It will be the responsibility of the highway transportation community at large to make the greater vision of a highway transportation system of the future a reality.

# SOMMAIRE

## HISTORIQUE

Ayant décidé de pousser les efforts de recherche et de développement dans le domaine des technologies reliées au transport routier de marchandises, le Centre de développement des transports (CDT), de Transports Canada, leur consacre un surplus de ressources financières, grâce à la décision du Ministère d'étoffer le budget de base du CDT à partir de l'année financière 1988-1989. Le but de la présente étude, lancée à la suite d'une décision prise en avril 1988, a été d'organiser cette nouvelle approche et aussi de susciter la participation coopérative du secteur privé.

## OBJECTIFS

Les objectifs fixés à cette étude étaient les suivants :

1. Aider le CDT dans la planification et la réalisation d'actions de R&D finalisées portant sur les technologies de transport routier des marchandises.
2. Faire un tour d'horizon des idées véhiculées dans ce domaine, accroître les efforts de recherche connexes et susciter la coopération entre les secteurs public et privé, et à l'intérieur de ceux-ci également.
3. Renseigner le secteur privé et les pouvoirs publics sur les objectifs de Transports Canada en matière de R&D et les éclairer sur le contexte dans lequel s'organisent et se réalisent les actions correspondantes.
4. Faciliter la coordination des programmes de R&D du CDT avec ceux des autres organisations actives dans le domaine de la R&D en transport routier de marchandises.

## PORTÉE

Ce rapport concerne le transport de marchandises par des transporteurs routiers pour leur propre compte ou le compte d'autrui, y compris les entreprises de déménagement qui utilisent d'habitude des véhicules dont le poids brut dépasse les 5 500 kg.

## MÉTHODES

Ce rapport interne du CDT s'alimente d'informations tirées de recherches documentaires, d'interviews personnelles auprès de nombreux spécialistes dans une vaste gamme de domaines ou bien de mémoires émanant de ceux-ci, c'est-à-dire hauts fonctionnaires de ministères fédéraux et de six gouvernements provinciaux, équipementiers, transporteurs routiers, représentants d'associations professionnelles et chercheurs aux niveaux fédéral, provincial et universitaire.

## LE SECTEUR RECHERCHE ET DÉVELOPPEMENT DU GOUVERNEMENT FÉDÉRAL

Le programme R&D de base de Transports Canada est géré par la Direction générale Recherche et développement qui en a confié la réalisation au CDT. Celui-ci a mis sur pied un programme de portée très vaste qui s'intéresse à tous les modes de transport. Le mandat du CDT est de compléter et d'élargir les actions de R&D lancées par les groupes opérationnels de Transports Canada à l'appui de leurs fonctions d'exploitation, de réglementation ou d'acquisition. C'est ainsi que le service chargé de veiller à la sécurité routière et à la réglementation des véhicules automobiles par exemple, mène un programme de R&D qui lui est propre et distinct du programme du CDT qui, notons-le, est presque entièrement imparti au secteur privé.

Le programme de R&D du CDT a été établi dans le but de permettre au gouvernement fédéral et aux divers organismes de Transports Canada d'atteindre les objectifs qu'ils se sont fixés, lesquels sont énumérés dans le tableau A ci-après, établi d'après le document "Priorités du ministère – 1988". Le Ministère est en train de revoir ces objectifs, mais il demeure que dans une perspective globale, sécurité et efficacité du réseau du transport, sûreté du transport des marchandises dangereuses, protection de l'environnement et développement régional figurent toujours au rang dfes préoccupations ministérielles.

Les travaux de R&D du CDT appartiennent à trois catégories : recherche exploratoire, recherche d'applications à long terme et recherche sectorielle. La R&D exploratoire vise à acquérir des connaissances par une évaluation systématique d'un large éventail d'innovations; la R&D d'applications à long terme vise des objectifs ministériels ou convenus avec les groupes opérationnels; la R&D sectorielle appuie les innovations qui, dans l'ensemble du secteur des transports, sont conformes aux priorités et aux objectifs du Ministère.

### TABLEAU A

### OBJECTIFS DU GOUVERNEMENT FÉDÉRAL ET DE TRANSPORTS CANADA DANS LE DOMAINE DES TRANSPORTS, PAR ORDRE DE PRIORITÉ

1. Améliorer la sécurité du réseau national de transport et la sûreté des transports, notamment, des marchandises dangereuses;
2. Favoriser et renforcer le développement économique national et régional;
3. Accroître la productivité et l'efficacité des transports;
4. Réduire la consommation par une utilisation rationnelle des ressources du pays;
5. Favoriser ou entreprendre des actions de R&D efficaces;
6. Encourager le commerce international;
7. Élaborer de nouveaux choix en matière d'investissement;
8. Protéger les investissements consentis dans le domaine des transports.

## STATISTIQUES

En 1986, les dépenses d'exploitation de l'industrie canadienne du camionnage se sont élevées à 12,3 milliards de dollars, comparativement aux 6,95 milliards (1984) dépensés par tous les réseaux ferroviaires du pays, y compris VIA Rail et aux 5,4 milliards (1985) par les lignes aériennes intérieures. Dans le secteur public, tous les paliers de gouvernement confondus, un total de 4,7 milliards (1986) ont été dépensés pour la construction routière et l'entretien des routes. En ce qui concerne le commerce avec les États-Unis, c'est par la route que se fait la plus grosse part des échanges, soit 59 p. 100 et 72 p. 100 des exportations et des importations, respectivement. Si l'on se base sur les dépenses d'exploitation pour mesurer les niveaux d'activité dans l'industrie du transport routier, les transporteurs routiers pour compte d'autrui et pour compte propre de l'Ontario ont engagé (à peu de chose près) 40 p. 100 du total à l'échelle canadienne, le Québec 18 p. 100, l'Alberta 13 p. 100, la Colombie-Britannique 11 p. 100 et les provinces de l'Atlantique 18 p. 100.

La majorité des entreprises de camionnage pour leur propre compte est constituée de transporteurs locaux qui utilisent surtout des camions, lesquels constituent plus de 89 p. 100 de leur parc d'unités motorisées. La majorité des transporteurs pour le compte d'autrui s'occupent surtout du transport interurbain de marchandises; leur parc est dominé par les tracteurs routiers à plus de 65 p. 100. Les statistiques de 1986 concernant les parcs provinciaux de véhicules montrent que la Colombie-Britannique dispose du parc le plus âgé, 75 p. 100 de ses camions datant de 6 ans ou plus, et que l'Ontario et le Québec possèdent les parcs les plus lourds étant donné que 20 p. 100 des véhicules y affichent une masse totale en charge (MTC) de 45 360 kg (100 000 lb) ou plus.

## RECHERCHE ET DÉVELOPPEMENT EN TRANSPORT ROUTIER DE MARCHANDISES

La mise sur pied d'un programme de R&D efficace dans le domaine du transport routier de marchandises passe nécessairement par une connaissance approfondie des attributions respectives des gouvernements fédéral et provinciaux dans le domaine considéré.

### RÔLE DU GOUVERNEMENT FÉDÉRAL

Le tableau B présente les lois fédérales régissant le transport routier. En plus de définir les champs de compétence, ces lois établissent les normes de performance et formulent les exigences auxquelles doivent satisfaire les entreprises concernées, les matériels mis en oeuvre et les modes d'exploitation. Quant au tableau C, il montre les principaux secteurs dont la responsabilité incombe au gouvernement fédéral.

La responsabilité directe du gouvernement fédéral en matière de transport routier résulte des lois indiquées au tableau B, de celles qui touchent directement à ce domaine (exemple, la Loi sur la sécurité ferroviaire en ce qui concerne les passages à niveau) et des ententes fédérales-provinciales de financement de projets particuliers en transports.

Mais le gouvernement fédéral intervient aussi de manière indirecte dans le domaine du transport routier lorsque celui-ci conditionne le succès de politiques ou d'initiatives fédérales dans des domaines parfois éloignés. Par exemple, le commerce et le tourisme ne sauraient se passer du transport routier et son influence sur l'aptitude des industries canadiennes à profiter de l'accord de libre-échange sera déterminante. Dans le domaine militaire, également, le transport routier joue un rôle essentiel, qu'il s'agisse de planification ou d'utilisation stratégique du réseau routier, de même que dans les cas d'urgence où la rapidité d'intervention est un facteur clé.

## TABLEAU B

## LOIS FÉDÉRALES RÉGISSANT LE TRANSPORT ROUTIER

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1. Loi sur le ministère des Transports;
2. Loi nationale sur les transports;
3. Loi sur le transport par véhicule à moteur;
4. Loi sur la sécurité des véhicules automobiles;
5. Loi sur la sécurité des pneus des véhicules automobiles;
6. Loi sur le transport des marchandises dangereuses;
7. Loi sur les normes de consommation de carburant des véhicules automobiles.

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Le gouvernement fédéral intervient indirectement en matière de transport routier lorsqu'il conclut des ententes de coopération avec les provinces dans le but de faciliter la réalisation de certains objectifs nationaux. Deux exemples intéressants de participation fédérale : le Conseil des ministres des transports et le Conseil canadien des administrateurs en transport motorisé.

## PROBLÈMES ET CRÉNEAUX DE RECHERCHE EN TRANSPORT ROUTIER

Un programme de R&D sur le transport routier de marchandises ne peut être vraiment efficace que dans la mesure où il est basé sur une étude des problèmes à résoudre et des créneaux de recherche susceptibles d'apporter la solution recherchée.

### Données sur les accidents

Les statistiques sur la sécurité routière récoltées par Transports Canada entre 1984 et 1986 montrent que les accidents impliquant des véhicules lourds ont été à l'origine du décès de 400 à 460 personnes chaque année et des blessures de 9 000 à 9 700 autres.

Devant la nécessité de réduire ces chiffres, on se trouve immanquablement face au dilemme de la meilleure affectation des ressources forcément limitées en vue d'en tirer le meilleur résultat possible. Ce dilemme est d'autant plus difficile à résoudre que les accidents routiers sont généralement le résultat d'un grand nombre de facteurs interreliés. C'est dire combien il est vital de disposer d'une base de données complète et cohérente sur les accidents et l'exposition aux risques d'accident, pour pouvoir mettre en évidence et évaluer les mesures de protection appropriées.

Partout au Canada, les accidents routiers entraînant perte de vie ou dommages corporels doivent faire l'objet d'un constat, de même que ceux qui entraînent des dommages matériels dont la valeur dépasse un certain seuil monétaire. Mais les lois qui s'y rapportent varient sur trois détails importants : le laps de temps suivant l'accident au bout duquel un décès cesse d'être attribué à celui-ci, la définition de dommages matériels entraînant l'obligation d'un constat, et le seuil de préjudice matériel à partir duquel une telle formalité devient obligatoire.

## TABLEAU C

## SECTEURS D'INTERVENTION DU GOUVERNEMENT FÉDÉRAL EN TRANSPORT ROUTIER

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**INTERVENTION DIRECTE**

1. Réglementation sur la sécurité des véhicules automobiles :
    a) réglementation des véhicules neufs, de la conception et la fabrication des pneus;
    b) programmes de rappels obligatoires en cas de défectuosités pouvant représenter un danger.
2. Réglementation sur le transport des marchandises dangereuses.
3. Réglementation sur le transport routier interprovincial.
4. R&D à l'appui du mandat de Transports Canada en transport routier.
5. Sécurité routière/ferroviaire et programme de protection des passages à niveau.
6. Programmes d'enseignement en matière de sécurité ferroviaire.
7 Construction et entretien des routes appartenant au gouvernement fédéral.
8. Fonds fédéraux remis aux provinces pour la construction routière.
9. Fonds fédéraux pour la sécurité routière.
10. Ponts pour le franchissement des voies navigables.
11. Circulation routière et infractions au Code criminel dans certaines provinces.

**INTERVENTION INDIRECTE**

1. Libre-échange et utilisation en commun du réseau routier.
2. Défense nationale et rôle stratégique du réseau routier.
3. Participation au Conseil des ministres des transports.
4. Participation au Conseil canadien des administrateurs en transport motorisé.

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De plus, l'obligation de procéder à un constat d'accident n'est pas interprétée partout de la même façon. Dans tous les cas, des directives existent sur les types d'accident qu'il faut obligatoirement constater mais elles sont imprécises quant aux détails que le constat doit enregistrer, sans compter que souvent elles souffrent d'un manque de cohérence lié au fait qu'elles émanent de différents organismes pouvant relever du fédéral, du provincial ou du municipal. Il arrive même parfois qu'un constat commencé par un agent soit achevé par un autre qui ne se trouvait pas sur les lieux.

Quant au formulaire utilisé, il a été conçu pour le constat d'accidents de voitures de tourisme. Il comporte d'habitude les rubriques suivantes : marque et modèle du véhicule, signalement des occupants et nature des blessures, lieu et heure de l'accident, conditions atmosphériques et trajectoire du véhicule juste avant l'accident. Mais lorsque le véhicule accidenté est un camion, on n'a aucune rubrique pour la description de celui-ci, de son chargement ou des états de service du conducteur. Et s'il s'agit d'un véhicule articulé ou d'un train double de type B, le constat ne distinguera, dans la plupart des cas, que le numéro de la plaque minéralogique, le certificat d'immatriculation ou le permis d'exploitation du tracteur. Il est rare que le constat distingue la remorque, à moins qu'il n'y ait une raison particulière pour le faire.

C'est pour toutes ces raisons que Transports Canada a créé le Fichier national sur les accidents et qu'il mis sur pied dix équipes multidisciplinaires d'investigation fonctionnant dans plusieurs universités canadiennes. Il ne reste plus qu'à affiner la base de données sur les accidents et à l'élargir de manière à lui donner un caractère interprovincial, voire national.

## Exposition au risque

L'évaluation juste et précise de l'exposition au risque nécessite une prise en compte cohérente et systématique des paramètres devant servir à caractériser le trafic et qui seront corrélés par la suite aux statistiques sur les accidents recueillies sur une période donnée. La configuration des véhicules est une autre donnée fondamentale pour garantir des résultats analytiques utiles facilitant la prise de décision. Pour ce faire, il faudra disposer d'un matériel de classification fiable, économique et condensant les informations dans un format pratique, et aussi d'un matériel permettant de stocker l'information une fois compilée et de l'exploiter.

Pour mettre sur pied un "système d'échantillonnage national", il faudra pouvoir disposer d'au moins ce qui suit :

1. Un réseau de postes de comptage fixes fonctionnant de façon ininterrompue et dont le nombre ainsi que les lieux d'implantation auront été choisis après une analyse de l'ensemble du réseau routier du pays. Le suivi statistique du trafic serait étendu à un échantillon représentatif de ce réseau, compte tenu du degré de fiabilité que l'on souhaite atteindre.

2. Un cadre statistique approprié permettant d'exploiter les stations de comptage fixes et mobiles de la manière qui convient, compte tenu des incidences saisonnières, météorologiques, d'évolution du trafic, etc. L'avantage des postes mobiles serait d'affiner le calage des facteurs de pondération utilisés par les postes fixes qui pourront ainsi accroître la précision des statistiques à court terme et cerner de plus près les tendances qui se dessinent à long terme.

Une province au moins, sinon deux, devront être invitées à participer à la création du réseau d'échantillonnage national, les autres s'y intégrant au fur et à mesure.

Le Canada trouvera là l'occasion d'innover en matière de collecte de données sur l'exposition au risque. Les progrès dans les domaines de la collecte de données ont été rapides grâce aux percées technologiques de ces derniers temps. Certaines provinces telles que le Québec, l'Ontario et la Saskatchewan cherchent maintenant à multiplier et à moderniser leurs installations de pesage de véhicules lourds. Il importe que tous les projets dans ce sens soient coordonnés dans l'optique d'une participation commune à la mise en oeuvre d'un système d'échantillonnage national qui intègre tous les moyens techniques actuels du pays ainsi que ceux à l'étude dans les différentes provinces. Sa réalisation nécessitera probablement des négociations fédérales-provinciales concernant certaines fonctions intéressant exclusivement le fédéral.

La conception et l'état des routes sont deux importants facteurs de risque que les statistiques sur les accidents et les données d'exposition au risque devront distinguer. C'est pourquoi il sera également nécessaire de trouver le moyen de localiser sur le réseau routier du pays les lieux où les accidents dus à ces deux facteurs sont les plus fréquents. Le degré de résolution correspondant sera conditionné par l'utilisation qu'on entend faire des données ainsi récoltées.

**Évaluation et diffusion technologiques**

Au Canada, la recherche sur les techniques de transport routier de marchandises est fragmentaire et elle n'a que rarement une portée internationale. De plus, les résultats ne parviennent pas toujours là où ils sont attendus.

Malgré tout, le Canada peut s'enorgueillir de son apport dans ce domaine; mais il lui reste à en faire la promotion dans les milieux internationaux que cette recherche intéresse.

Pour être dans la course, les entreprises de transport canadiennes doivent apprendre à profiter des dernières découvertes avec le maximum d'économies. Étant donné qu'une forte proportion des découvertes dans le domaine du transport routier se fait à l'étranger, la tâche de repérer celles qui répondent le mieux aux besoins et de les assimiler est vitale.

Le transfert réussi de ces technologies ne pourra se faire sans la concertation planifiée et structurée des secteurs public et privé. Il incombe au secteur public d'aider le secteur privé en analysant l'évolution probable des technologies tant au pays qu'à l'étranger et en mettant en évidence celles qui promettent le plus pour relancer l'économie nationale et affermir la position concurrentielle de ses industries sur le marché mondial.

Il est dans l'intérêt des secteurs public et privé de favoriser la coopération des chercheurs canadiens et les échanges internationaux de technologie dans les secteurs où cela promet d'avoir un effet bénéfique sur l'économie nationale. Dans le domaine des technologies nouvelles, par exemple, notamment la robotique, l'informatique et la télématique, le Canada devra scruter avec soin les applications possibles, qu'il s'agisse de gestion du trafic (signalisation, gestion des autoroutes, application des règlements), de repérage et de commande des véhicules ou même de l'autoroute électronique de l'avenir qui promet de faire du véhicule, de son conducteur et de la route un tout inséparable. Ces technologies viendront bouleverser tous les paramètres connus ainsi que ceux qui conditionnent les coûts, et ce seront elles qui détermineront dans une large mesure les services de transport qui pourront être assurés et aussi la manière de les assurer. L'Europe, les États-Unis et le Japon ont consenti de très grands efforts de R&D pour mettre au point des produits de haute technologie qu'ils diffuseront sur les marchés dès que leur valeur aura été reconnue. Il est donc de l'intérêt du Canada de participer à ces recherches en fonction de ses besoins et de son potentiel technologique afin d'être en mesure, lui aussi, de fabriquer ces produits et d'en approvisionner non seulement ses propres marchés, mais aussi les marchés extérieurs.

**Véhicules**

Le produit intérieur brut (PIB) du secteur transports — tous modes confondus — représente à l'heure actuelle 4,8 p. 100 du PIB total du Canada. C'est là un grand progrès depuis 1971, année où le PIB de ce secteur représentait 7,1 p. 100 du total, mais il demeure qu'il est encore aujourd'hui de près de 50 p. 100 plus élevé au Canada qu'aux États-Unis. La productivité du secteur transport routier se doit donc de progresser davantage afin que le Canada puisse demeurer concurrentiel, et que s'accroisse la part du Canada dans le transport routier de marchandises nord-sud. Les deux domaines susceptibles de faire progresser la productivité sont ceux de la standardisation réglementaire et de l'électronique appliquée aux transports.

À part la productivité, la sécurité des véhicules lourds promet, elle aussi, de profiter des progrès de l'électronique appliquée aux transports. Les statistiques sur l'immatriculation et les accidents montrent que les véhicules lourds comptent pour quelque 3,5 p. 100 de tous les accidents à déclarer et pour 10 p. 100 du nombre total de tués par suite d'un accident routier. Le public est préoccupé non seulement par la proportion élevée des accidents de poids lourds avec des morts, mais aussi par le fait que c'est pratiquement toujours la ou les personnes qui occupaient l'autre voiture, le plus souvent une voiture de tourisme, qui y trouvent la mort ou qui sont grièvement blessés. Pour leur part, les entreprises de camionnage trouvent, elles aussi, une cause d'inquiétude dans les études faites en Europe et aux États-Unis qui montrent que, dans le secteur du camionnage, le taux de tués par an qui est de 58 par 100 000 travailleurs est le plus élevé après celui du secteur des mines et carrières où ce taux est de 60 par 100 000. Dans l'ensemble du secteur industriel, le taux moyen est de 11 par 100 000 travailleurs.

Grâce à l'électronique embarquée, il sera possible à l'avenir de suivre l'état de santé et la condition physique du conducteur, et de l'avertir de situations anormales; de surveiller le comportement dynamique du véhicule et d'avertir le conducteur dès le début de situations potentiellement dangereuses; de surveiller l'état des organes de sécurité et de rappeler au respect du programme d'entretien préventif et curatif. L'électronique embarquée permettra en outre d'optimiser les performances par une surveillance étroite de la transmission, de la suspension et des freins, de déterminer les itinéraires en fonction des statistiques sur les débits et de veiller au respect des consignes de chargement et d'arrimage.

Dans le secteur du camionnage, la sécurité routière touche à un grand nombre de paramètres qui, à leur tour, conditionnent d'autres facteurs secondaires : stabilité de marche, réponse dynamique, agressivité, résistance aux collisions, freinage, ergonomie, visibilité, entretien et fiabilité.

Les axes de recherche et de développement préconisés dans ce domaine et énoncés en termes généraux, sont les suivants :

1. Améliorer la sécurité par des caractéristiques destinées à réduire l'agressivité, accroître la résistance aux collisions et à mieux protéger les occupants; à relever l'efficacité des systèmes de freinage, et, par une meilleure ergonomie, accroître la pilotabilité et faciliter l'insertion dans le trafic.

2. Améliorer le comportement dynamique des véhicules articulés, leur stabilité de marche et leur pilotabilité par l'application des normes de poids et de dimensions, l'élaboration de normes applicables aux attelages, l'emploi de mécanismes de direction d'essieux de remorque actifs ou semi-actifs, l'étude de dispositifs empêchant la mise en portefeuille, la mise au point de modèles permettant l'analyse du comportement dynamique des véhicules articulés et l'étude de dispositifs antiballottement améliorés à l'intérieur des camions-citernes.

3. Améliorer la dynamique des suspensions par l'utilisation de méthodes d'essais universellement reconnues; l'approfondissement des paramètres concernant la suspension et l'analyse de leur influence combinée sur la stabilité de marche et la pilotabilité ainsi que l'étude de suspensions assurant une stabilité accrue.

4. Approfondir l'effet global des véhicules articulés sur l'interface chaussée-suspension.

5. Accroître les économies d'énergie par des techniques réduisant le frottement à l'intérieur des moteurs et transmissions, par le relèvement du rendement énergétique des poids lourds, l'emploi d'énergies de substitution, l'évaluation des carburants et additifs, par des formes plus aérodynamiques réduisant la traînée et, enfin, la réduction des imbrûlés dans les gaz d'échappement.

6. Perfectionner l'électronique embarquée.

7. Lancer une étude de faisabilité sur un véhicule routier de type avancé bénéficiant des recherches les plus récentes dans tous les domaines, et à laquelle participerait le plus grand nombre possible d'établissements de recherche du pays.

8. Accroître la productivité des véhicules à usage spécialisé comme les transporteurs de véhicules, les fourgons, les fourgonnettes, les véhicules forestiers, les trains routiers ainsi que les conteneurs de type multimode, par une conception et une exploitation améliorées.

## Infrastructures routières

À l'heure actuelle, les dépenses fédérales au chapitre de la construction et de l'entretien des infrastructures routières s'élèvent à 225 millions de dollars par an. Et aux termes des ententes déjà conclues, le gouvernement fédéral participera, aux cours des quinze prochaines années, au financement des projets provinciaux de construction routière à hauteur de 1,233 milliards de dollars. Le gouvernement fédéral devient ainsi l'un des principaux bailleurs de fonds routiers au Canada, dépensant à lui seul plus que la somme des dépenses routières annuelles combinées de six des dix provinces canadiennes. Aussi, Transports Canada devra-t-il faire preuve de circonspection et assortir ses objectifs d'acquisition et de financement de critères de sécurité et d'entretien destinés à alléger ses obligations financières dans le temps et, en même temps, de veiller à ce que les découvertes techniques dans le domaine de la construction et de la maintenance routières soient mises en oeuvre.

Mais toute recherche sur les infrastructures routières devra se faire conjointement avec les provinces. Tant le Strategic Highway Research Program (SHRP) que le Programme stratégique de recherche routière du Canada (C-SHRP), auxquels Transports Canada participe, s'intéressent à la réfection et à l'entretien du réseau routier. Toutefois, ces deux programmes ne vont pas jusqu'à faire ressortir l'influence des normes de conception sur la sécurité routière, ni à établir des liens entre les accélérations verticales des véhicules et l'endommagement des chaussées et des ponts.

Les axes de R&D préconisés dans le domaine des interactions véhicules-infrastructures et des normes de conception routière, énoncés en termes généraux, sont les suivants :

1. Approfondir le comportement dynamique des véhicules chargés et de leurs suspensions et analyser les interactions véhicules-chaussées, en vue de réduire celles-ci par des véhicules de conception améliorée.

2. Mettre au point des techniques permettant de réduire l'agressivité des véhicules à l'égard des chaussées et, de la sorte, alléger les contraintes financières pesant sur les secteurs public et privé.

3. Mettre au point de nouveaux matériaux de construction routière permettant d'améliorer les rendements énergétiques et de remplacer les matériaux ayant un impact négatif sur l'environnement ou résistant mal aux phénomènes de corrosion.

4. Moderniser les normes relatives à la signalisation routière et aux caractéristiques géométriques des routes, les rendre compatibles avec la nouvelle génération de véhicules lourds et normaliser les panneaux de signalisation à messages variables.

5. Participer aux programmes do SHRP et C-SHRP et à l'objectif d'un réseau routier de conception, de construction, d'entretien et de rendement améliorés.

6. Assurer l'appui du gouvernement fédéral à une norme nationale pour la localisation des accidents et à la mise en oeuvre de cette norme par des contrôles appropriés applicables aux projets de construction routière financés par l'État.

7. Rendre les normes concernant le mobilier routier compatibles avec les voitures de tourisme allégées et à traction avant, et avec la nouvelle génération de véhicules lourds.

8. Trouver des revêtements routiers susceptibles de réduire les projections d'eau sans pour autant sacrifier d'autres caractéristiques désirables.

9. Élaborer un manuel d'entretien du mobilier routier, d'utilisation obligatoire au niveau des routes construites grâce à des fonds fédéraux.

**Contrôles routiers**

Les provinces et les territoires exploitent quelque 150 postes de pesage fixes, 150 bascules mobiles et 50 bascules de pesage dynamique. Avec un personnel de 900 personnes environ, le budget annuel total correspondant approche les 300 millions de dollars. Dans la plupart des cas, ce personnel fait plus que le simple pesage des véhicules lourds : il contrôle les immatriculations, les assurances, les taxes de vente sur les carburants, les permis d'exploitation du transporteur, le permis de conduire du conducteur, les certificats d'inspection, l'état mécanique du véhicule, l'affichage concernant les matières dangereuses, les fiches d'instruction, les permis d'exploitation particuliers et le respect des dimensions. Avec l'entrée en vigueur du Code national de sécurité, ce contrôle portera bientôt sur le nombre d'heures de service.

Lorsque des infractions aux codes provinciaux sont constatées, des actions au civil sont intentées contre le propriétaire du véhicule, celui qui l'exploite ou le conducteur. Étant donné que les intimés contestent souvent les accusations portées contre eux, les responsables du pesage doivent veiller à ce que la preuve déposée devant les tribunaux soit convaincante. Or, la définition des diverses infractions au Code de la route peut varier d'une province à une autre, selon que le règlement afférent se présente sous telle ou telle forme. On comprend donc la difficulté d'élaborer une manière de procéder en poursuite ou en défense qui débouche sur des résultats uniformes à l'échelle nationale. Toutefois, il existe des axes de R&D susceptibles d'accroître la précision et la rapidité des contrôles routiers, notamment :

1. Mettre au point des normes nationales concernant le pesage statique, le pesage à bord et le pesage dynamique.
2. Mettre au point, et éprouver, un système intégrant une identification automatique de véhicules et un contrôle des antécédents infractionnels, de manière à permettre aux inspecteurs routiers de dresser sur le champ les contraventions qui s'imposent.
3. Mettre au point une bascule de bord améliorée, permettant l'exploitation maximale d'un véhicule sans dépasser les limites permises.
4. Améliorer les techniques du pesage dynamique pour réduire les coûts et rehausser la précision et la fiabilité des contrôles faits à vitesses élevées pour ne pas retarder le trafic, et augmenter le nombre de fonctions automatisées pour réduire la main-d'oeuvre nécessaire.

**Techniques d'exploitation**

Ce secteur englobe un grand nombre de questions, qu'il s'agisse du rendement des conducteurs ou de l'exploitation des véhicules ou des parcs de véhicules.

Les spécialistes de la sécurité routière s'accordent à dire qu'entre 70 et 80 p. 100 des accidents routiers sont attribuables à une erreur de la part du conducteur. On s'attache maintenant à déterminer les causes d'accidents routiers de manière plus systématique que dans le passé.

Au Canada, le Code national de sécurité traite, notamment, des questions concernant la classification des permis de conduire, la formation des conducteurs et les épreuves auxquelles ces derniers sont soumis, des infractions et de l'échange de documents entre autorités compétentes et, enfin, des heures de service. Par contre, les facteurs ergonomiques ayant une incidence sur la sécurité routière n'y figurent pas encore, les recherches les concernant n'étant pas concluantes.

Au niveau de l'exploitation, de réels progrès sont prévisibles dans les secteurs de la régulation et du repérage des véhicules. Les techniques actives de repérage ne sont pas encore tout à fait intégrées à l'exploitation, au point de permettre le calcul automatique des itinéraires et de communiquer automatiquement avec le conducteur en chemin. Ce type de communication requiert une liaison en mode vocal qui permettrait au conducteur de transmettre ses coordonnées au poste de contrôle. Une liaison passive entre le véhicule et un centre de régulation informatisé qui assurerait le repérage automatique des véhicules permettrait, grâce à un système expert, de modifier l'itinéraire ou l'horaire établi, de manière à tirer un rendement optimal du parc exploité. Cette même technique de repérage pourrait servir à situer les cargaisons dans l'optique de la généralisation des techniques de production à flux tendus (ou à stock zéro). Enfin, elle promet de nombreuses autres applications, qu'il s'agisse de planification routière, de transport de marchandises dangereuses, de guidage des automobilistes ou de communications de secours.

Les axes de recherche préconisés dans ce domaine sont les suivants :

1. Approfondir le comportement du conducteur et ses limites, ainsi que ses réactions à des perceptions et des stimuli extérieurs, notamment aux téléphones cellulaires, écrans vidéo et systèmes de guidage qui équiperont bientôt la cabine.
2. Utiliser l'ergonomie pour combattre la fatigue du conducteur et accroître sa vigilance à tout ce qui risque de se passer autour de lui.
3. Mettre au point des techniques d'aide à la formation, à l'appréciation des aptitudes et à la délivrance des permis, et d'autres qui permettront aux exploitants de respecter les normes d'efficacité minimales au regard du Code national de sécurité.
4. Mettre au point des systèmes de surveillance de la santé et de la condition physique des conducteurs ainsi que des systèmes de comptage des heures de service, dont le but est d'améliorer le rendement des conducteurs.
5. Mettre au point des aides à la conduite qui améliorent la pilotabilité en avertissant le conducteur de l'approche de situations potentiellement dangereuses : changements de la hauteur du centre de gravité de la remorque, oscillations de celle-ci ou renversement de l'ensemble.
6. Accroître la sécurité dans le transport de marchandises dangereuses par des techniques d'essais non destructifs, des techniques de protection plus efficaces, de meilleures communications, des méthodes d'identification plus sûres et une utilisation plus généralisée de systèmes experts pour une réponse plus rapide à une situation dangereuse.
7. Utiliser la télématique pour optimiser les fonctions reliées à la régulation du trafic, la gestion des parcs, les bureaux mobiles et l'information routière, et pour faire un usage optimal du réseau routier, notamment autour des grands noeuds routiers.

## PROGRAMME DE R&D EN TRANSPORT ROUTIER DE MARCHANDISES PROPOSÉ POUR LE CDT

L'étude d'un programme de R&D en transport routier de marchandises que le CDT pourrait adopter a nécessité la prise en considération des créneaux de R&D possibles dans le contexte des objectifs et des priorités du gouvernement fédéral et de Transports Canada, ainsi que du mandat confié au CDT. Il a fallu également tenir compte des attributions du gouvernement fédéral en matière de transport routier. De tout ceci, et après concertation avec les autorités fédérales et provinciales concernées, le secteur privé et les associations industrielles, il a été possible de dégager un programme de R&D en transport routier de marchandises que le CDT pourrait prendre en charge et qui aurait l'objectif général suivant :

> "Entreprendre et favoriser des programmes coopératifs de recherche, de développement ainsi que de démonstration dans le domaine de la sécurité et de la productivité des véhicules routiers lourds, et en ce qui concerne leur impact sur

les infrastructures routières et les techniques d'exploitation sans oublier le transport des marchandises dangereuses, l'efficacité énergétique et l'utilisation d'énergies de substitution."

Les sous-objectifs correspondants proposés sont les suivants :

1. Mettre au point des systèmes et des techniques de collecte de données utiles sur les accidents de véhicules lourds et l'exposition aux risques d'accidents.
2. Favoriser l'évaluation et la diffusion systématiques des découvertes technologiques dans le domaine du transport routier de marchandises.
3. Faire avancer la recherche sur les techniques favorisant la sécurité et la productivité du transport routier de marchandises.
4. Faire avancer les recherches concernant les effets de l'infrastructure routière sur le transport routier de marchandises sur la conception de véhicules utilitaires.
5. Favoriser l'application de techniques nouvelles ou améliorées en vue d'accroître la fiabilité et la rapidité des contrôles routiers au regard de la réglementation nationale afférente.
6. Lancer des recherches sur les techniques avancées de transport routier et d'ergonomie appliquée au transport routier dans le but d'accroître la sécurité et la productivité de ce secteur au Canada, et de mettre celui-ci à l'heure des technologies naissantes.

## CONCLUSION

Les occasions de faire avancer le transport routier de marchandises par la recherche et le développement technologiques sont aussi nombreuses que variées. Elles concernent pratiquement toutes les facettes de l'industrie et d'elles dépendront, au bout du compte, la compétitivité de ce secteur par rapport aux autres modes de transport ainsi que la réaction du public à sa présence de plus en plus importante sur le réseau routier de la nation.

Compte tenu des fonds limités que le Centre de développement des transports peut affecter à la R&D en transport routier de marchandises, il va de soi que le CDT accordera la priorité aux travaux allant dans le sens du mandat confié à Transports Canada en matière de transport routier. Par conséquent, il appartient à l'industrie du transport routier en général de faire en sorte que se concrétise le projet global du réseau de transport routier du futur.

# TABLE OF CONTENTS

TITLE PAGE ........ i
DISCLAIMER ........ ii
PUBLICATION DATA FORM ........ iii
FORMULE DE DONNÉES POUR PUBLICATION ........ iv
ACKNOWLEDGEMENTS ........ v
AN INVITATION TO THE CANADIAN TRANSPORTATION COMMUNITY ........ vii
SUMMARY ........ ix
SOMMAIRE ........ xxi

## PART I
## INTRODUCTION

Background ........ 1
Objectives ........ 1
Scope ........ 1
Methodology ........ 2
Contents and Organization of Report ........ 2
Authors' Note ........ 2

## PART II
## HIGHWAY FREIGHT TRANSPORT IN CANADA: AN OVERVIEW

**Chapter**

1. CANADIAN TRUCKING INDUSTRY OVERVIEW ........ 3
  1.1 For-Hire Trucking ........ 3
  1.2 Private Trucking ........ 3
  1.3 Power Units ........ 4

1.4 Trucking Industry by Province or Territory of Domicile .................. 4
1.5 Changes in Industry Activity .................. 4
1.6 Canada – United States Trade Regional Share of Exports .................. 5
1.7 Canada – United States Trade Modal Analysis .................. 5
1.8 Foreign Control of For-Hire Trucking Firms .................. 6
1.9 Truck Manufacturing .................. 6

## PART III
## RESEARCH AND DEVELOPMENT OBJECTIVES AND PRIORITIES IN THE FEDERAL GOVERNMENT

2. GOVERNMENT OBJECTIVES AND PRIORITIES .................. 7

3. TRANSPORT CANADA'S OBJECTIVES AND PRIORITIES .................. 9

3.1 Corporate Objectives and Priorities .................. 9
3.2 Regulatory Objectives .................. 11
3.3 Operational and Procurement Objectives .................. 13

4. TRANSPORT CANADA'S RESEARCH AND DEVELOPMENT (R&D) OBJECTIVES AND PRIORITIES .................. 15

4.1 R&D Considerations .................. 15
4.2 Corporate R&D Objectives and Priorities .................. 16
4.3 R&D Resource Allocation .................. 16

5. TRANSPORTATION DEVELOPMENT CENTRE'S R&D MANDATE AND ACTIVITIES .................. 19

5.1 TDC's R&D Mission .................. 19
5.2 R&D Program Organization .................. 19
5.3 Operational Plan Overview .................. 20
5.4 Funding .................. 21

## PART IV
## RESEARCH AND DEVELOPMENT OPPORTUNITIES IN HIGHWAY FREIGHT TRANSPORT TECHNOLOGIES

6. EXPOSURE AND ACCIDENT DATA .................. 23

6.1 Data Collection and Applications .................. 23

6.2 Development of Accident Countermeasures ........................ 25
6.3 Canadian Situation ........................ 27
6.4 United States Experience ........................ 33
6.5 Australian Experience ........................ 33
6.6 European Experience ........................ 33
6.7 Potential R&D Opportunities ........................ 35

7. TECHNOLOGY ASSESSMENT AND DIFFUSION ........................ 39

7.1 Canada ........................ 39
7.2 Europe ........................ 41
7.3 United States ........................ 42
7.4 Australia ........................ 43
7.5 Potential R&D Opportunities ........................ 44
  7.5.1 Technology Assessment ........................ 44
  7.5.2 International Technology Exchange ........................ 44
  7.5.3 Coordination of Canadian Research ........................ 45
  7.5.4 Emerging Technologies for Traffic Management ........................ 45
  7.5.5 Emerging Technologies for Vehicle Monitoring and Control ........................ 45
  7.5.6 Interprovincial Communications and Systems Interfacing ........................ 45

8. VEHICLE TECHNOLOGY RESEARCH ........................ 49

8.1 Vehicle Stability and Dynamic Response ........................ 50
8.2 Loading Standards ........................ 52
8.3 Improved Design for Dynamic Performance ........................ 52
8.4 Aggressiveness ........................ 53
8.5 Crashworthiness ........................ 55
8.6 Braking ........................ 57
8.7 Driver Awareness ........................ 60
8.8 Ergonomics ........................ 61
8.9 Conspicuity ........................ 62
8.10 Improved Maintenance ........................ 64
8.11 Truck Electronics ........................ 66
8.12 Potential R&D Opportunities ........................ 66
  8.12.1 Vehicle Safety ........................ 66
  8.12.2 Combination Vehicle Dynamics ........................ 66

8.12.3 Suspension Dynamics ........ 68
8.12.4 Interface Between Roadway and Suspension ........ 68
8.12.5 Energy and Environmental Conservation and Fuels Substitution .. 68
8.12.6 On-Board Electronics ........ 68
8.12.7 Advanced Integrated Vehicle Technology Feasibility Study ........ 68
8.12.8 Productivity of Special Purpose Vehicles ........ 69

9. INFRASTRUCTURE TECHNOLOGY RESEARCH ........ 71

9.1 Potential R&D Opportunities ........ 72
9.1.1 Dynamics of Vehicle Loads and Suspensions ........ 72
9.1.2 Technology to Minimize Vehicle Contribution to Road Wear ........ 73
9.1.3 Alternative Materials for Pavements and Structures ........ 73
9.1.4 C-SHRP and SHRP ........ 73
9.1.5 Highway Geometrics ........ 73
9.1.6 National Accident Location System ........ 73
9.1.7 Roadside Furniture Specifications ........ 74
9.1.8 Influence of Pavements on Splash and Spray ........ 74
9.1.9 Furniture Maintenance Handbook ........ 74

10. COMPLIANCE TECHNOLOGY RESEARCH ........ 75

10.1 Potential R&D Opportunities ........ 75
10.1.1 National Standard for Highway Scales ........ 75
10.1.2 Automatic Vehicle Identification and Provincial Records ........ 76
10.1.3 On-Board Weigh Scale Technology ........ 76
10.1.4 Weigh-in-Motion Scales ........ 76

11. OPERATIONAL TECHNOLOGY RESEARCH ........ 77

11.1 Driver Performance Technologies ........ 77
11.2 Vehicle and Fleet Operational Technologies ........ 77
11.3 Potential R&D Opportunities ........ 78
11.3.1 Driver Behaviour and Limits of Performance ........ 78
11.3.2 Ergonomics and Human Factors Engineering ........ 78
11.3.3 Driver Training and Evaluation Technologies ........ 78
11.3.4 Driver Monitoring Systems for Medical and Physical Conditions ........ 78
11.3.5 Driving Aids for Improved Vehicle Control ........ 78
11.3.6 Dangerous Goods Transportation ........ 78

11.3.7 Fleet and Traffic Management ............................... 79

11.3.8 Travel Advisory and Optimization of Highway System Use Around Principal Transportation Hubs ..................... 79

11.3.9 Mobile Office ........................................ 79

## PART V

## PROPOSED OBJECTIVE AND SUB-OBJECTIVES OF TDC R&D PROGRAM IN HIGHWAY FREIGHT TRANSPORT TECHNOLOGIES

Background ........................................................ 83

Program Development Considerations ....................................... 84

Proposed Program Objective ................................................ 84

Proposed Program Sub-Objectives ........................................... 85

Conclusion ........................................................ 85

APPENDIX A REFERENCES ..................................................... A–1

APPENDIX B 1988–89 TDC OPERATIONAL PLAN RELATING TO HIGHWAY TRANSPORT ..................................... B–1

APPENDIX C PROPOSED 1989-90 TDC OPERATIONAL PLAN RELATING TO HIGHWAY TRANSPORT ..................................... C–1

# LIST OF TABLES

Table 1 Objectives and Priority Programs of Policy Sectors Affecting Transport Canada ..... 8

Table 2 Overall Federal Government Priorities ..... 8

Table 3 Transport Canada's Corporate Priorities ..... 9

Table 4 Specific Transport Canada Programs Concerned with Highway Vehicle Safety and Productivity ..... 10

Table 5 Federal Government Legislation Dealing with Highway Transportation ..... 11

Table 6 Principles of National Transportation Act of 1987 ..... 11

Table 7 Provisions of Motor Vehicle Transport Act of 1987 ..... 12

Table 8 Interdepartmental Energy Research and Development Policy Program for 1989 Through 1994 ..... 18

Table 9 TDC R&D Program Organizational Groupings ..... 20

Table 10 Difficulties Associated with Development of Accident Countermeasures ..... 26

Table 11 Possible Benefits of Proper Use of a Sound Accident and Exposure Data Base ..... 27

Table 12 Potential Exposure Data Sources ..... 28

Table 13 Proposed Exposure Data Base Description for National Classified Traffic Counting Data ..... 30

Table 14 Proposed Exposure Data Base Description for Periodic National Surveys of Travel by Light-Duty Vehicles ..... 31

Table 15 Proposed Exposure Data Base Description for Periodic National Surveys of Travel by Heavy Trucks ..... 32

Table 16 Accident Data Base Description ..... 34

Table 17 Potential Areas for Increased Collection of Heavy Truck Exposure and Acccident Data ..... 36

Table 18 Potential Areas for Increased Collection of Heavy Truck Exposure and Acccident Data ..... 37

Table 19 Several Key RTAC Committees ..... 41

Table 20 Several Completed OECD Initiatives ..... 42

Table 21 Summary Description of Some Transportation-Related Projects Under the European EUREKA Program ..... 43

Table 22 Areas of Study for Potential Application of Emergent Technologies ..... 44

Table 23 Potential Applications of Emerging Computer and Communication Technologies to Traffic Management ..... 46

Table 24 Potential Applications of Emerging Computer, Robotic and Communication Technologies to Vehicle Monitoring and Control ..... 47

Table 25 Opportunities for Improving Truck Braking Performance .................. 58
Table 26 Truck Electronic Systems Predicted by TRW Inc. Study .................. 67
Table 27 Potential Applications of Communication and Computer Technologies in Support of Fleet Management .................................... 80
Table 28 Potential Applications of Communication and Computer Technologies in Support of Travel Advice ........................................ 81
Table 29 Potential Applications of Communication and Computer Technologies in Support of the Mobile Office .................................. 82
Table 30 Federal Priorities and TDC Mandate ................................ 84
Table 31 Federal Responsibilities in Highway Transportation ..................... 86
Table 32 TDC's Highway Freight Transport Technology R&D Program ............... 87

# PART I

# INTRODUCTION

## BACKGROUND

Transport Canada's Transportation Development Centre (TDC) has slated highway freight transport technology as an area for increased research and development (R&D) activity and will allocate additional resources to it. This is in response to the increasing role of highway freight transport in Canada's economy and the public's increasing awareness of its potential effects on highway transportation overall.

## OBJECTIVES

This report presents the results of a study, which TDC decided to undertake in April 1988, with the following objectives:

1. To provide a précis of current thinking on R&D areas of opportunity, to help promote expansion of related activities and to encourage cooperation among Canadian researchers within, and between, the public and private sectors.
2. To provide the private sector and all levels of government with an understanding of the R&D objectives of Transport Canada, and the associated context within which Transport Canada's central R&D activities are developed and conducted.
3. To assist TDC to plan and execute focused R&D activities relating to highway freight transport technology.
4. To facilitate coordination of TDC's R&D program with that of other organizations that are involved with highway freight transport R&D.

## SCOPE

This report addresses freight vehicle transport that, though non-specific, generally refers to the operation of commercial vehicles by private and for-hire trucking firms and household goods moving companies, normally at gross weights in excess of 5 500 kg. It considers the vehicles, the roadway network (i.e. pavements and bridges), the operational management of freight vehicles and driver performance, and the interaction of freight vehicles with the roadway and other highway traffic.

## METHODOLOGY

After work was begun in April 1988, a literature survey was conducted in-house to identify necessary background material, current issues and potential future trends and developments.

Interviews were conducted with experts and written comments were solicited from representatives of various federal departments, six provincial governments and various manufacturers, operators, industry associations and researchers in federal, provincial and university laboratories.

Presentations of preliminary results were made, and comments were requested, at the meeting of the Council on Highway Transportation Research and Development (CHTRD) held in Winnipeg on 11 June 1988 and at the Roads and Transportation Association of Canada (RTAC) annual meeting held in Halifax on 25 September 1988.

The vast quantity of information generated was reviewed and analyzed by the authors for selective incorporation into this final report.

## CONTENTS AND ORGANIZATION OF REPORT

Current technological issues in highway freight transport are examined with reference to the current state of the industry. Potential opportunities for research and development are presented and described from a broad perspective. These opportunities cover the range of technologies relating to vehicle, driver, infrastructure, operations, compliance with regulations and collection of exposure and accident data. Technology assessment and diffusion is discussed with a view to the needs of government and industry.

Research and development in highway freight transport technologies is also set in the context of federal government and Transport Canada departmental objectives, priorities and responsibilities. From this perspective, objectives and sub-objectives for an R&D program to be conducted by TDC are proposed that respond to the federal government mandate and to industry needs.

The report is organized into five sections. This introduction is Part I. Part II provides an overview of highway freight transport in Canada, citing some pertinent industry statistics. Part III discusses federal government objectives and priorities and sets federal R&D in this context. The mandate of the Transportation Development Centre is also reviewed therein. Part IV examines current issues in highway freight transport technologies, potential future trends and developments. This part is divided into six chapters covering exposure and accident data, technology assessement and diffusion, vehicle technology, infrastructure technology, compliance technology, and operational technology. Part V in effect represents the conclusion of the report. It proposes objectives and sub-objectives for an R&D program to be conducted by TDC.

## AUTHORS' NOTE

The authors wish to apologize beforehand to the reader for their failure to include so much interesting and useful information on the subjects dealt with herein, and many other subjects not mentioned. Highway transportation R&D in general is experiencing explosive activity worldwide, and much of it will affect freight transportation. Unfortunately, there is never enough time to do everything and a great deal of information cannot be squeezed into the few pages that the reader can effectively absorb.

With this in mind, readers are urged to do their own investigations and join TDC in this exciting research.

# PART II

# HIGHWAY FREIGHT TRANSPORT IN CANADA: AN OVERVIEW

## 1. CANADIAN TRUCKING INDUSTRY OVERVIEW

The latest Canadian trucking industry data available from Statistics Canada, for 1986, includes the following highlights (1)*.

### 1.1 FOR-HIRE TRUCKING

Statistics were compiled for for-hire truckers having gross operating revenues over $100 000.

The total operating revenues of for-hire truckers increased 5.1% from 1985 to a 1986 total of $8.6 billion. Total operating expenses increased 4.6% over the same period of time to $8.2 billion. Salaries and drivers' wages accounted for 19.5% of operating expenses.

More than 70% of the for-hire trucking firms were involved in the intercity movement of freight. These firms earned more than 89% of total industry revenues.

In 1986, the proportion of international movements accounted for over $1.3 billion, or 14.2% of the total operating revenues of these firms.

The revenues earned from domestic intercity commodity movements increased 5.6% from $4.8 billion in 1985 to just over $5.0 billion in 1986. Intraprovincial movements remained the dominant type of these movements, accounting for 57% of total domestic intercity revenues earned.

Total tonnage carried by for-hire truckers increased by 16.4% over 1985. This represents the largest tonnage increase recorded in four years.

A seven-year analysis (1980 through 1986) of growth and operating performance of the for-hire trucking industry shows that operating revenues, in constant 1981 dollars, decreased by 3%. Corresponding expenses decreased by 4.7%. During this period, the industry showed a relatively stable profit margin ranging between 3.2 and 4.9%, with the exception of 1982 when it dropped to 2.5%.

### 1.2 PRIVATE TRUCKING

Statistics were compiled for private carriers having at least 15 vehicles. These 2 676 private carriers had $4.1 billion in operating expenses in 1986, with the average expenses per firm being $1.5 million.

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* The numbers appearing within brackets refer to references listed in Appendix A.

Carriers domiciled in Quebec and Ontario accounted for 66% of the total industry operating expenses, and represented 60% of the total number of carriers. The private sector spent more than 31% of its operating expenses on the salaries and wages of drivers.

The majority of private trucking firms (59%) were local carriers who accounted for $2.6 billion (63.4%) of the total operating expenses. These carriers purchased 93% of all piggyback services and 85% of all vehicle rentals.

Carriers domiciled in Quebec and Ontario accounted for 57% of the total private industry distance (2.2 billion km) travelled in 1986.

## 1.3 POWER UNITS

More than 90% of the power unit fleet owned by private carriers is comprised of straight trucks. Road tractors dominate the for-hire fleet (65%).

Average distance travelled with straight trucks is significantly shorter for private carriers. Using 250 working days per year, the private carriers averaged 95 km a day, compared to 145 km for the for-hire truckers. This is an indication that local service is a more common practice for private truckers.

## 1.4 TRUCKING INDUSTRY BY PROVINCE OR TERRITORY OF DOMICILE

Province or territory of domicile refers to the physical location of the carrier, and not necessarily the area where the trucking activity of the carrier takes place.

Most of the for-hire carriers are domiciled in Quebec (24% of all for-hire carriers) and Ontario (25%). However, the carriers domiciled in Ontario accounted for 40% of the total operating expenses, which is more than twice the percentage for carriers domiciled in Quebec (18%). This is a clear indication that carriers domiciled in Ontario are larger than those domiciled in Quebec. Alberta and British Columbia domiciled the same percentage of the total for-hire carriers (18%). Alberta carriers had 13% of the total for-hire operating expenses, British Columbia had a share of 11%, Manitoba and Saskatchewan accounted for 12% and the Atlantic provinces for 6%.

Over 60% of all private truckers were domiciled in Ontario and Quebec in 1986, and they accounted for 65% of all private trucking operating expenses. Alberta and British Columbia had 24% of the private trucking carriers and 23% of the private trucking operating expenses.

These statistics indicate that the for-hire and private trucking sectors are dominant, in number of carriers and operating expenses, in four provinces — Quebec, Ontario, Alberta and British Columbia.

## 1.5 CHANGES IN INDUSTRY ACTIVITY

Major changes occurred in the traffic pattern for both trucking sectors between 1985 and 1986. The for-hire trucking firms increased their tonnage by over 16%, from 160.8 million tonnes in 1985 to 187.2 million tonnes in 1986. Meanwhile the tonnage transported by private operators decreased approximately 6%, to 68.6 million tonnes in 1986.

Ontario and the region comprised of British Columbia and the Territories registered the most significant for-hire tonnage increases in 1986, as regions of origin as well as destination. The volume carried to British Columbia and the Territories in 1986 was 29.4% higher than in the previous year. Similarly, the tonnage transported from this region increased 27.8%. The total weight of movements to and from Ontario rose by approximately 28%.

In 1986, private carriers reduced their volume carried to and from Ontario and Quebec by approximately 11 to 12%.

## 1.6 CANADA — UNITED STATES TRADE REGIONAL SHARE OF EXPORTS

Over 93% of all exports from Canada's Atlantic region are directed to the Northeastern and Southern regions of the United States or to the Eastern seaboard states. In comparison, the Atlantic region of Canada receives only 5.1% of the goods exported from these states.

Almost half (48.9%) of Quebec exports are destined for the Northeastern region of the United States. The Northeastern and North Central regions of the United States receive more than three quarters of Quebec exports.

The majority of goods exported from Ontario (54.9%) are destined for the North Central states. The North Central and Northeastern regions of the United States receive 76.5% of Ontario exports.

Ontario receives 73.5% of the total United States exports to Canada. Ontario's share of exports to Canada from various United States regions ranges from 49.5% from Western states to 83.2% from North Central states.

Interestingly, the Western provinces exported more of their goods (39.8%) to the North Central states than to the neighboring Western states or remaining United States regions.

## 1.7 CANADA-UNITED STATES TRADE MODAL ANALYSIS

For statistical purposes, transport modes in Canada are categorized as truck, rail and others. "Others" include marine, air and pipeline.

For Canada's trade with the United States, truck transport dominates with 58.9% of the exports and 72.1% of the imports as measured by the value of merchandise transported. Rail transports a quarter of the exported goods while carrying only 11.7% of the imports.

Over 45% of Canada's trade with the United States is with the North Central states. The bulk of this, 65.4% of exports and 70.9% of imports, is transported by truck.

Rail generally carries a higher proportion of the goods exported compared to those imported. Rail's share of export traffic ranges from a low of 18.8% for the Western states to a high of 28.9% for the Northeastern states.

Given the availability of marine transport along either coast, it is not surprising that the "other" mode grouping has almost equal proportions of the Canadian exports and imports for the Western states (38.6 and 34.4%, respectively) while, for the Northeastern states, the proportion is 15% in both directions of trade flow.

Data clearly indicates the dominance of trucking in carrying Canadian imports, ranging from a high of 74.9% for Ontario and a minimum of 60.2% for the Atlantic provinces.

The Atlantic provinces trade mostly with the Northeastern states (72.7% of exports, 39.6% of imports). Almost 50% of the exports and approximately 75% of the imports are carried by truck.

Rail maintains 49% of the exports shipped from the Atlantic provinces to the North Central states, compared to only 5.2% of the goods imported.

The availability of marine transport to the Atlantic provinces has kept the proportion of the "other" mode category strong, with 38.3% of exports and 34.5% of imports.

Quebec trade flows are almost equal in both directions with the Northeastern states. In this trade, 64.3% of the exports and 84.4% of the imports are transported by truck.

## 1.8 FOREIGN CONTROL OF FOR-HIRE TRUCKING FIRMS

Foreign-controlled trucking firms were generally comparable in 1986 to class 1 carriers (those carriers with domestic intercity revenues of $3 000 000 and over). The rationale for this type of comparison is that class 1 average gross operating revenues were $10.8 million in 1986, while the average gross operating revenues generated by the foreign-controlled firms identified by CALURA (Corporation And Labour Union Relations Act) was $16.3 million. In comparison, the 1986 average gross revenues for class 2 carriers (those carriers with domestic intercity revenues of at least $350 000 and under $3 million) were $1.1 million, and the figure for the class 3 carriers (those carriers with domestic intercity revenues of at least $100 000 and under $350 000) was $0.2 million.

Based on the CALURA source, 40 foreign-controlled trucking firms were domiciled in Canada in 1986. This number represents 6.7% of the class 1 carriers and 0.6% of the for-hire trucking firms. However, these 40 companies produced revenues of $651 million in 1986, which is 10.6% of class 1 carrier revenue and 7.5% of the total revenues received by the Canadian for-hire trucking industry covered by the Motor Carriers of Freight Survey (MCF).

From 1981 to 1982 the foreign-controlled firms collected between 14.4 and 15.0% of the revenues of class 1 carriers. In 1983 there was a significant drop to 10.7% of total class 1 revenues. Since then, this proportion has remained stable.

The foreign-controlled trucking firms experienced steady financial growth over the six years ending in 1986. The average revenue of these firms rose from $10.8 million in 1981 to $16.3 million in 1986, an increase of 51%. The class 1 trucking firms followed the same trend, but to a much lesser extent. Class 1 average revenues increased by 10% from 1981 to 1986.

Foreign-controlled carriers spent less on transportation and maintenance and more on terminal and administration expenses in 1986 than their Canadian-owned counterparts. The foreign firms spent almost twice the amount on terminal expenses. This expenditure trend remained relatively stable from 1981 to 1986.

In 1986, the revenue class 1 firms spent 61.7% of their total expenses on transportation and 8.7% on terminal expenses. On the other hand, the foreign firms spent 53.5% of their total expenditures on transportation and 14.6% on terminal expenses. Also, the Canadian firms spent, proportionally, a greater amount on vehicle maintenance than the foreign firms.

## 1.9 TRUCK MANUFACTURING

The production of new trucks has increased by 61.5% between 1980 and 1986. Between 1981 and 1986, annual sales of commercial vehicles increased 46%. During the same period, imports of all trucks and chassis increased by 61.8% while exports increased 12.5%. Provincial registration statistics show that, in 1986, British Columbia had the oldest fleet, with 75% of the trucks 6 years old or more. Ontario and Quebec had the heaviest fleet, with 20% of vehicles having a gross vehicle weight designation of 100 000 pounds or more.

# PART III

# RESEARCH AND DEVELOPMENT OBJECTIVES AND PRIORITIES IN THE FEDERAL GOVERNMENT

## 2. GOVERNMENT OBJECTIVES AND PRIORITIES

The government has both legal obligations and announced policies respecting surface transportation. Its legal obligations stem from the British North America (BNA) Act of 1867, which sets out the government's responsibilities in surface transportation as:

1. establishing transportation links which cross provincial boundaries;
2. undertaking such works as are declared to be for the general advantage of Canada;
3. regulating interprovincial commerce; and
4. providing for national defence.

Under these legal responsibilities, the federal government has seen fit to construct interprovincial and international bridges and interprovincial highways, and to impose federal regulations governing new motor vehicles and their components, the transportation of dangerous goods and interprovincial commerce.

Federal highway programs have helped to create employment from 1919 to the mid-1940's, have improved the interprovincial highway systems from 1949 to 1971 and have encouraged regional development between 1958 and 1970 and from 1974 to the present.

The government has organized its programs into eight policy sector envelopes, each of which is provided with its own objectives and priorities. Transport Canada is within the Economic and Regional Development Envelope. The general objectives of this envelope (2) that affect Transport Canada are given in Table 1.

Within the remaining seven policy sector envelopes, four broad objectives and programs exist (3) which affect the activities of Transport Canada. These are also presented in Table 1.

The government has, in addition, set continued restraint in government spending, reduction in the Public Service and tax reform as current priorities within its fiscal policies.

Transport Canada programs are developed and progress under consideration of overall federal government objectives and priorities (5), which are summarized in Table 2.

## TABLE 1

## OBJECTIVES AND PRIORITY PROGRAMS OF POLICY SECTORS AFFECTING TRANSPORT CANADA

### ECONOMIC AND REGIONAL DEVELOPMENT ENVELOPE

1. Stimulation and encouragement of private sector investment in the orderly development, production and disposition of Canada's primary natural resources.
2. Encouragement of increased innovation and research and development.
3. Provision for regional and industrial development.
4. Promotion of a positive climate for the creation and expansion of business enterprises.

### SOCIAL DEVELOPMENT ENVELOPE

5. Programs of assistance for people who are disabled.
6. Programs responding to environmental needs of Canadians.

### EXTERNAL AFFAIRS AND AID ENVELOPE

7. Promotion of Canadian economic growth through trade negotiations, trade, and foreign investment initiatives.

### SERVICES AND GOVERNMENT ENVELOPE

8. Construction and maintenance of roads and bridges under federal jurisdiction.

## TABLE 2

## OVERALL FEDERAL GOVERNMENT PRIORITIES

1. Economic growth
2. Deficit reduction
3. Regional development
4. International trade
5. Science and technology
6. Tax reform
7. Economic regulatory reform

## 3. TRANSPORT CANADA'S OBJECTIVES AND PRIORITIES

### 3.1 CORPORATE OBJECTIVES AND PRIORITIES

Transport Canada's corporate objectives and priorities (5) are intended to reflect those of the government as well as the department's. Given the progression of government objectives, and the department's legal and moral commitments, Transport Canada's plans and initiatives tend to be evolutionary. Thus there are annual changes in emphasis rather than major revisions.

In 1985, Transport Canada's major policy directions were economic regulatory reform and safety. In 1986, security (particularly at airports), communications and support of trade in transportation services replaced economic regulatory reform, but safety remained a priority issue. Again in 1987 safety remained the top focus of departmental activity, while additional emphasis was placed on marine policy initiatives and on encouraging the private sector to participate more vigorously in international trade.

Transport Canada's 1988–89 corporate priorities are presented in Table 3. The corporate objectives can be summarized as to make the transportation sector safer, more efficient and more responsive to the diverse needs of shippers and the travelling public. Corporate priorities for 1989–90 are presently being updated but on-going concerns, from an overall perspective, continue to deal with safety, efficiency, security, transport of dangerous goods, environment, and regional development.

Within the broad priorities, a number of specific programs focus on highway vehicle safety and productivity (4, 5). These are presented in Table 4.

TABLE 3

TRANSPORT CANADA'S CORPORATE PRIORITIES

1. To ensure a safe transportation system for both public and private users.
2. To propose initiatives that create a balanced and better economic environment.
3. To improve internal and external communications.
4. To ensure Transport Canada continues to live within its short-term and long-term net expenditure reference levels.
5. To ensure shippers and carriers become familiar with the new regulatory environment and interpretations of the new National Transportation Act.
6. To ensure the new National Transportation Agency is set up in the spirit of the new environment.
7. To clarify the extent to which, and the means by which, Transport Canada is to evaluate and oversee the privatization of its Crown corporations.
8. To ensure Canadian shippers' and carriers' interests are served and strengthened in the free trade agreement with the United States.
9. To encourage international standardization of transport equipment, and regulatory and operating rules.
10. To support the export of Canadian transportation expertise and equipment worldwide.
11. To study marine policy issues that may require change.

## TABLE 4

## SPECIFIC TRANSPORT CANADA PROGRAMS CONCERNED WITH HIGHWAY VEHICLE SAFETY AND PRODUCTIVITY

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1. Development of a comprehensive safety strategy including evaluation of priorities on a multi-modal basis, allocation of resources, key performance indicators, consultation and passage of the Transportation Accident Investigation Board Act and detailed recommendations for a federal-provincial National Safety Code.
2. Continued improvement of the safety of motor vehicle travel through the development and enforcement of safety standards, accident and defect investigations and public education.
3. Development of initiatives aimed specifically at school bus and heavy truck safety, and at further improvements in occupant restraint systems.
4. Continued development of regulations respecting packaging and containers for dangerous goods, through research and consultation.
5. Expansion and improvement of the dangerous goods compliance program.
6. Consolidation and strengthening of the role of CANUTEC (Canadian Transportation Emergency Centre) for emergency response.
7. Maintenance of constructive relationships with the provinces in order to achieve a unified national dangerous goods program.
8. Stimulation of economic activities in those regions that are experiencing slow growth.
9. Support for the National Transportation Agency's monitoring of the effects of economic regulatory reform during the years 1988 to 1991 inclusive, through joint data collection, analysis and studies.
10. Implemention of cooperative programs on topical highway and vehicle safety issues with the provinces, industry, research institutes and universities, including, but not limited to:
    a. effort to increase road safety and uniform practices by assisting the provinces in the implementation of the National Safety Code;
    b. promotion of safety practices (e.g. use of seat belts, use of infant safety seats, anti-drunk-driving campaigns) and safety standards (e.g. maintenance of exhaust emission control devices);
    c. continued cooperative efforts to train Dangerous Goods Inspectors by providing funds to the provinces;
    d. collaboration with industry in setting enforceable Dangerous Goods Standards;
    e. monitoring of safety trends as economic regulatory reforms are implemented; and
    f. improvement of public awareness of safety through informational campaigns.

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## 3.2 REGULATORY OBJECTIVES

Transport Canada's authority for its federal highway role stems from legislation listed in Table 5. The National Transportation Act (NTA) and its companion, the Motor Vehicle Transport Act (MVTA), became law on January 1, 1988. These aim to use competition and the free market as agents for promoting efficient and adequate transportation services at the lowest possible cost. The NTA deals primarily with the railways, but does include provisions for interprovincial bus and truck operations. The NTA and MVTA have principles and objectives as presented in Tables 6 and 7 respectively (7, 8).

TABLE 5

**FEDERAL GOVERNMENT LEGISLATION DEALING WITH HIGHWAY TRANSPORTATION**

1. Department of Transport Act
2. National Transportation Act (1987)
3. Motor Vehicle Transport Act (1987)
4. Motor Vehicle Safety Act
5. Motor Vehicle Tire Safety Act
6. Transportation of Dangerous Goods Act
7. Motor Vehicle Fuel Consumption Standards Act

TABLE 6

**PRINCIPLES OF NATIONAL TRANSPORTATION ACT OF 1987**

1. The national transportation system is to meet the highest practical safety standards.
2. The prime agents in providing sound and effective transportation services are to be competition and the market forces.
3. Economic regulation is to occur only for those services and those regions where economic regulation is required to serve the transportation needs of shippers and travellers.
4. A commercially sound transportation link is recognized as a key to regional economic development objectives.
5. Each mode of transportation is to bear its fair share of the resources it utilizes that are provided at public expense.
6. Each mode of transportation is to receive fair compensation for costs borne as a result of publicly imposed duties.
7. Access to transportation is a basic necessity that is not to be hindered by undue obstacles, unfair disadvantages or unreasonable discouragements.

**Motor Vehicle Safety Act (MVSA) and Motor Vehicle Tire Safety Act (MVTSA)**

These acts (9, 10) regulate the design, identification, construction and functioning of new vehicles, their components and tires, either shipped into Canada or across a provincial boundary for retail sale. The purpose of the acts is to ensure people are protected against personal injury, impairment of health and death. The MVSA provides for the recall of components that fail to meet safety standards or are judged to have a safety-related defect. The MVSA also ensures that maximum exhaust and evaporative emission levels of new motor vehicles manufactured in or imported into Canada do not exceed the maximum levels specified for hydrocarbons, carbon monoxide and oxides of nitrogen. Most provincial governments have enacted complementary legislation requiring all new vehicles manufactured and sold within their jurisdictions to meet the MVSA.

TABLE 7

PROVISIONS OF MOTOR VEHICLE TRANSPORT ACT OF 1987

1. Provincial governments are to adopt a uniform entry test for licensing extra-provincial truck operators.
2. The fit, willing and able test is to be administered for granting extraprovincial truck operating licences to be issued after January 1, 1988.
3. A National Safety Code that determines the fitness of the licencees is to be adopted by the provinces before January 1, 1993.
4. Insurance, familiarity with provincial and dangerous goods legislation, mechanical condition and compliance with provincial and dangerous goods requirements are to be included in the fitness criteria.
5. A four-year transition period (January 1, 1988 to December 31, 1991) is provided during which a "likely" detrimental effect on the "public interest" is the criteria for refusing a licence (reverse onus test).
6. The National Transportation Agency is to conduct annual reviews for the years 1988 through 1991, inclusive, to determine the effect of economic and regulatory reform.
7. In the period of 1991 to 1993 a review of the reverse onus test is to be conducted, to determine if it will continue to be administered.
8. Rates and conditions of licence are to be removed by the end of the transition period.

**Motor Vehicle Fuel Consumption Standards Act (MVFCA)**

This act (11) promotes a reduction in the annual consumption of petroleum by light duty vehicles. It does this by monitoring the average fuel consumption of all vehicles sold in Canada by each manufacturing and importing company, and by informing the public of the fuel consumption ratings of all new cars on the Canadian market. This act was passed by Parliament in June 1982 but was never proclaimed. Most of its provisions are being adhered to on a voluntary basis.

**Dangerous Goods Act (DGA)**

This act (12) and complementary provincial legislation have recently been enacted to promote public safety in the handling, offering for transport, transport, packaging, classification and identification of dangerous goods. This legislation is the result of an intense, cooperative effort among the federal, provincial and territorial governments as well as the industry affected. As responsibilities for controlling and regulating transportation are shared, the federal, provincial and territorial governments are working together to ensure that dangerous goods regulations are uniform across the country, and apply equally to all modes of transport: air, marine, rail and road.

## 3.3 OPERATIONAL AND PROCUREMENT OBJECTIVES

In road transportation, Transport Canada has both direct and arm's length interests in bridges over navigable waters and in improving surface transportation systems. These interests result from the Primary Highway Strengthening and Improvement Program and Economic and Regional Development Agreements (ERDAs). These interests are to improve interprovincial connections, assist economic development in regions that have fallen behind national standards, and provide bridges between isolated population concentrations. Financial assistance is provided to the provinces, within the context of ERDAs, through Transportation Subsidiary Agreements and other bilateral agreements. Within the next 12 years these fiscal contributions to the provinces could reach $500 million per year. These agreements include major initiatives in Quebec and Atlantic Canada to upgrade and maintain federal bridges and upgrade the numbered highway systems.

# 4. TRANSPORT CANADA'S RESEARCH AND DEVELOPMENT (R&D) OBJECTIVES AND PRIORITIES

Transport Canada must exercise prudence in allocating its limited resources to achieve its corporate objectives. It is therefore essential that advanced technologies be considered when specifying systems, equipment or infrastructure needed to satisfy regulatory, operational and procurement needs. Technological innovation can be promoted through a systematic process of identifying opportunities and conducting fundamental and applied research. Once completed, the research findings must be disseminated among the transportation community, and opportunities must be provided to implement the results.

## 4.1 R&D CONSIDERATIONS

Transport Canada's research and development (R&D) priorities are derived in consideration of the following national strategic R&D priorities.

### Economics

The world and national economies are undergoing major changes. In many cases, these changes will permit the orderly evolution of transportation services and related technologies, equipment and systems. In some cases, the changes could be dramatic. Changes in markets and demands for Canadian raw and semi-processed materials, free trade with the United States, and the new national transportation policy "Freedom to Move" could lead to changes in rail, trucking and air transportation services, and patterns of operation. The prospects for development of policies concerning Arctic oil and gas, to enhance Canada's Arctic sovereignty, continue to require Arctic marine transportation R&D.

Technological innovation will have major effects in the safety and productivity of all modes. New signalling, communication, and control technologies, based on the application of sophisticated micro-electronics and computer systems, will increase the efficiency and effectiveness of transportation. Such innovation will also lead to changes in organizations, jobs, and employment levels.

### Government Science and Technology Policy

The government has outlined three categories of federal science and technology programs: those designed to support and/or stimulate technological innovation in the private sector; those required to meet the government's mission requirements; and those designed to support and/or strengthen Canada's science and technology infrastructure.

The objectives and scope of Transport Canada's R&D program are derived from its corporate mission. R&D activities must be developed to support the corporate operational, regulatory and procurement (Capital Investment Plan) objectives, and to stimulate innovation in safety throughout the transportation sector.

Transport Canada's first Annual Science and Technology Plan (ASTP), developed in 1987, reflected this aspect in response to the government's science and technology policy. The National Advisory Board on Science and Technology and the ministers approved Transport Canada's ASTP, but required Transport Canada to develop a more comprehensive R&D

strategy to support procurement. This strategy aims at early identification, through R&D, of opportunities for technological innovation related to the aviation and marine group capital investment plan 10 to 15 years in the future. It would continue to support applications-oriented engineering R&D, and to apply state-of-the-art technology in the context of these procurement plans.

### Commercialization

Transport Canada's procurement-related R&D has a direct effect on domestic and foreign investment in new transportation equipment and systems. Corporate annual investment of $11 million in procurement R&D supports equipment and systems purchases valued at $400 million. Corporate safety R&D has a less direct, but nonetheless tangible, effect on commercial investment in the transport sector. Corporate exploratory and long-range R&D activities support its objectives and enable industry to position itself for long-term corporate investments.

## 4.2 CORPORATE R&D OBJECTIVES AND PRIORITIES

Transport Canada's R&D objectives are intended to reflect the need for technological innovation by:

1. stimulating as much research activity as possible within the available resources; and
2. optimizing the potential benefits of this research in improving transportation safety, economy and effectiveness.

Priority activities within the R&D objectives are those activities that:

1. achieve timely technological innovation in support of departmental policy, operational, regulatory or procurement objectives;
2. contribute to the government's objectives in energy, improved access for people who are elderly and people who are disabled, and industrial and regional development;
3. promote and facilitate timely technological innovation in the Canadian transportation community; and
4. foster cooperation with other federal departments, other levels of government, industry, universities, other countries and international agencies.

## 4.3 R&D RESOURCE ALLOCATION

Corporate resources are allocated among the different Transport Canada research and development programs according to controlled allotments for core research, operational R&D, energy R&D and federal-provincial transportation subsidiary agreements.

### Centralized Core R&D Program

To hasten the advancement of technologies, Transport Canada will make a sustained commitment to R&D through a centralized Core R&D Program, beginning in 1988. The Core R&D Program will consist of: exploratory R&D into emergent technologies and disciplines, long-term application R&D in support of departmental needs, and sector-directed R&D in support of corporate and federal policies. Subject to final approvals, the Core R&D Program will be allocated $7 million in fiscal year 1988-89, $9 million in fiscal year 1989-90 and the greater of $9 million or 1.25% of capital costs in subsequent fiscal years. The Core R&D Program is intended to complement, not replace, existing R&D initiatives within the operational groups needed to support their operational, regulatory and procurement needs. Up to 50% of the resources allotted to the Core R&D program will be allocated to exploratory R&D. The remaining funds will be distributed between long-term applications R&D and sector-directed R&D in accordance with departmental policy and priorities, and operational group advice.

Exploratory R&D is intended to produce knowledge through wide-ranging systematic assessment of new developments. The aim is to identify technological innovations with potential to improve transportation system elements. The methods include technology scanning, technology forecasting, technology assessments, experimental testing and consultative workshops and symposia. The investigations are frequently high-risk, require continuous long-term monitoring and involve a wide spectrum of clients, R&D performers and collateral interest groups.

Long-term applications R&D consists of programs undertaken by the central R&D directorate in support of departmental or agreed group objectives. These programs will generally last for several years, but could include any agreed-upon application R&D program. This R&D could also be in support of departmental capital investment plans. The inspiration for individual projects will be operational group needs and the results of the exploratory R&D program.

Sector-directed R&D supports innovation in the transportation sector at large that contributes to departmental objectives and priorities. The purposes of these programs will be determined by corporate and broader policy direction concerning safety, productivity, energy, accessibility, regional development and environmental factors in the transport modes. Sector-directed R&D may, for example, address long-term highway infrastructure and heavy vehicle safety and productivity issues. It would be implemented through cooperative research with provinces, industry and other federal departments and agencies.

### Energy R&D Program

In 1985 the government announced an interdepartmental Energy Research and Development Policy Program for 1986 through 1991. The program initially maintained a high priority on fossil fuel and energy conservation and sustained projects of long-term research into hydrogen, fusion and renewable energy resources. Two years remain in the original program, and the government's policy has since recognized the need to sustain a diversity of environmentally compatible energy supply and efficient use opportunities, regionally balanced, for the short, medium, and long terms. This policy is supported by a revised five-year program for 1989 through 1994, with re-allocations and increased funding for the remaining years of the original program. The specific objectives of the revised federal program are presented in Table 8.

Transport Canada intends to continue its active support of the government's energy R&D program by allocating $5.5 million in each of the next five years. These allocations will pursue complementary energy and transportation sector objectives in the fields of conservation, development of alternative fuels and transportation of energy commodities. Particular emphasis will be placed on system safety and system efficiency. Technological innovation will be initially pursued through the corporate energy R&D program, in the areas outlined in Table 8.

The primary focus of Transport Canada at present is on fuel conservation measures for highway transport vehicles (buses and heavy trucks) through the application of systematic technical improvements and better operating procedures. Considerable importance is also being given to research that ensures the availability of alternative fuels and alternative fuel engines. The associated infrastructures must meet or exceed the efficiency, performance, safety and environmental standards of conventional fuels and vehicles. This will ensure a safe and efficient introduction of alternative fuels and engines.

TABLE 8

## INTERDEPARTMENTAL ENERGY RESEARCH AND DEVELOPMENT POLICY PROGRAM FOR 1989 THROUGH 1994

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**OBJECTIVES**

1. Provide technical support to federal policies and programs in energy, efficiency, renewable energy, diversified transportation fuels, hydrogen and electricity.
2. Enhance fusion programs cost-shared with the governments of Ontario and Quebec.
3. Address heightened concerns on short and long-term environmental issues related to energy supply and use.
4. Begin to address regional imbalances in program delivery by establishing a Quebec presence for laboratories of the Canadian Centre for Mineral and Energy Technology (CANMET).

**AREAS FOR TECHNOLOGICAL INNOVATION**

1. Long-term transportation fuel use policy.
2. Measures to improve energy efficiency in transportation vehicles, ways and terminals.
3. Measures to promote safe and economic introduction of non-petroleum fuels.
4. Measures to support finding safe and adequate transportation for energy commodities.

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### R&D in Federal-Provincial Subsidiary Agreements

In December 1984, the federal government and the province of Quebec signed an Economic and Regional Development Agreement (ERDA). In July 1985 the two governments signed a $170 million ERDA Subsidiary Agreement on Transportation Development that included $15 million, over five years, for transportation R&D.

The objectives of the R&D program of the subsidiary agreement are:

1. to increase transportation R&D in Quebec;
2. to strengthen the transportation equipment manufacturing sector in Quebec; and
3. to increase the productivity, competitiveness and technological development of the Quebec transportation system.

Projects are funded equally by both governments. They must meet the objectives of the subsidiary agreement in the sectors specified by it, and must be acceptable to both governments.

The four sectors covered by the program are road transportation, rail transportation, micro-electronics and computers, and intermodal transportation.

A major ERDA achievement was marked in October 1987 with the signing of a $1.3 million agreement between Voyageur Inc. and the two governments for a two-year bus demonstration using new Canadian articulated bus technology.

# 5. TRANSPORTATION DEVELOPMENT CENTRE'S R&D MANDATE AND ACTIVITIES

The Transportation Development Centre (TDC) was formed by Transport Canada in 1970 to study, promote and manage the application of science and technology towards a safer, more efficient and effective Canadian transportation system. TDC administers an ongoing program of research and development activities, most of which is contracted out to the private sector.

## 5.1 TDC'S R&D MISSION

TDC's mission is two-fold (13):

1. to provide components of Transport Canada with specific data, research and demonstration projects to assist operational, regulatory, policy planning and evaluation functions; and
2. to undertake exploratory R&D addressing requirements in transportation technology and systems that are long-term, high-risk and national in scope.

TDC's activities form a key part of the R&D functions assigned to the Research and Development Directorate (DGRD), which in turn forms part of the responsibilities assigned to the Policy and Coordination Group.

Responsible to the Director General - Research and Development, TDC conducts its R&D program in accordance with Transport Canada's directives. These directives address R&D priorities and requirements in support of departmental activities, federal science and technology policy and, to a certain extent, the Canadian transportation industry, where justified under existing government policies. A new R&D council is to be established to provide a new focus for R&D management within Transport Canada, which will enable TDC to broaden its scope of activities.

Recent federal policy decisions regarding science and technology, together with Transport Canada's commitment to sustaining a centrally managed Core R&D Program, provide new direction for development and management of TDC's R&D activities.

## 5.2 R&D PROGRAM ORGANIZATION

TDC's program of R&D activities is organized into the seven groups listed in Table 9, corresponding to a modal area or special transportation issue.

The TDC operational plan is organized into activity areas, each described in terms of its objectives, sub-objectives and specific targets for the year. The funding allocations for each area indicate the relative intensity of the R&D effort. The plan also incorporates exploratory R&D, long-term applied R&D and sector-directed R&D, as discussed previously under R&D Resource Allocation. Special Programs include the Economic and Regional Development Agreement (ERDA) projects and a federal contribution agreement with Canada Coach Lines.

TABLE 9

TDC R&D PROGRAM ORGANIZATIONAL GROUPINGS

1. Rail.
2. Marine.
3. Air.
4. Highway.
5. Transportation for elderly and disabled persons.
6. Multimodal.
7. Special Programs.

ERDA projects are considered separately since they require the agreement of both the federal and provincial governments, and since provincial governments are primarily responsible for project implementation.

## 5.3 OPERATIONAL PLAN OVERVIEW

Due to the timing of TDC's planning cycle, this overview pertains to the operational plan for the 1988-89 fiscal year, which is detailed in Appendix B for highway-related activities. For information purposes, this discussion includes transportation for elderly and disabled persons and multimodal transport, both of which have important highway-related activities.

Appendix C presents an initial draft of TDC's proposed 1989-90 operational plan for highway-related activities.

The program involving transportation for people who are elderly and people who are disabled remains essentially the same as last year, with slightly augmented financial resources. Research thrusts are accessible vehicles and communications and technical aids. More work on technology for travellers who are visually or communication-impaired is planned. The application of expert systems and micro-electronic technologies to facilitate travel shows great promise.

A major new initiative, in collaboration with Canada Coach Lines, is the demonstration of accessible bus service in the Kitchener-Buffalo corridor.

A major $1.3 million articulated intercity bus demonstration program, formerly grouped under the highway plan, is now listed under the Canada-Quebec ERDA section.

Due to augmented resources, important R&D areas are being strengthened. In addition, more emphasis will be placed on enabling technologies such as electronics (remote sensing radars, electro-optics and lasers, power electronics, communications, control, measuring devices and transducers, status monitoring, etc.), computers (engineering, design, analysis, simulation and modelling, graphics, expert systems, etc.), materials (composites, ceramics, lubricants, tribology and superconducting technology) and ergonomics (man-machine interaction and human factors such as fatigue).

The highway program stresses cooperative research with the provinces and the private sector to foster a coordinated national approach to highway R&D and the minimization of total system costs. Highway transport R&D, with emphasis on heavy vehicle safety and stability, electronics and communication technology, transportation of dangerous goods and energy conservation and substitution, constitutes a significant element of this program. TDC is currently contributing $100 000 each year for five years to the Canadian Strategic Highway Research Program (C-SHRP) which is linked to, and ensures access to, the results of the United States Strategic Highway Research Program (SHRP).

## 5.4 FUNDING

TDC's operational plans are defined largely by the resources available in each fiscal year. TDC's base budget for 1988-89 is $7 million, representing a 34% increase over the previous fiscal year. External funding sources will increase the R&D budget to $14 million. Funding from Supply and Services Canada and from the Transportation of Disabled Persons Program is expected to increase, while funding from other groups within Transport Canada; Energy, Mines and Resources Canada, and other sources (provinces, cities and other federal departments) is expected to decrease. With a possible $2.2 million for ERDA projects, the estimated maximum R&D funds potentially available to TDC for 1988-89 amount to $21.2 million.

Some resources have been left uncommitted, building a degree of flexibility into the plan. This allows TDC to undertake new initiatives in response to unforeseen opportunities in transportation R&D.

TDC has planned a $14 million (excluding ERDA) R&D program in five key areas: marine (25%), air (20%), highway (19%), rail (15%) and transportation for people who are elderly and people who are disabled (9%). The remaining R&D areas (7%) involve minor activities principally intended to maintain a technical base and monitoring on behalf of Transport Canada. Projects conducted under the Canada-Quebec ERDA, listed separately from the core-funded R&D activities, are planned at $2.2 million. If fully implemented, these ERDA projects will raise the total program level to over $16 million.

# PART IV

# RESEARCH AND DEVELOPMENT OPPORTUNITIES IN HIGHWAY FREIGHT TRANSPORT TECHNOLOGIES

## 6. EXPOSURE AND ACCIDENT DATA

### 6.1 DATA COLLECTION AND APPLICATIONS

The development and application of vehicle safety standards or other road safety measures should be based on as complete an understanding as possible of the perceived problems they are intended to address.

Two types of data are required to provide the basis for rational interventions in the road transportation system that are intended to improve safety. Accident data describe the specific circumstances and consequences of accidents. Exposure data describe the general incidence of factors that are associated with the occurrence of accidents. These two types of data may be combined to give measures of the risk of particular types of accidents, or consequences in various circumstances.

**Accident Data**

Accident data are commonly classified by the level of detail they include and by certain associated characteristics. Level I accident data are commonly collected by police forces, primarily for judicial purposes. In principle, the resulting reports constitute a census, i.e. a 100 percent sample, of the legally reportable accidents within the relevant jurisdiction. The level of detail is limited and the accuracy and completion rates of the coded data are often less than ideal for analytical purposes. Various techniques are available for creating enhanced Level I data. One method is to recode the data from a copy of the police report, making maximum use of the accident diagram and the narrative. Another involves the use of an independent agency to confirm the coded data and, where possible, to supply missing data. A third method enhances the data by linking the accident file to one or more existing data bases that contain information on the vehicle, the driver and the victims.

Level II accident data are characterised by the use of accident report forms that are much more detailed than those normally used by the police. They are completed by trained investigators, typically within a period of 72 hours after the accident. Where possible, involved vehicles are inspected, survivors are interviewed and injury severity data are recorded. Ideally, a probability sample of accidents is investigated. The principal advantage of Level II data lies in their greater reliability and additional detail. For reasons of cost, however, relatively few accidents are usually investigated and the may not constitute a probability sample. In either event, the utility of the additional detail in the data may be severely limited either by the large sampling errors associated with small samples of accidents or by a completely undefined statistical relationship to the general accident population.

The principal respect in which Level III accident data differ from Level II is in the level of detail in the investigations and, consequently, in their cost. Level III investigations are usually begun at the accident site within minutes of the occurrence of the accident and typically involve quite exhaustive enquiries into the circumstances and consequences of the accident. For purposes of quantitative analysis, Level III data are of even less use than Level II data since, in general, they have no statistical validity and hence allow no inferences to be made about the accident population from which the cases have been drawn.

### Exposure Data

Exposure data describe the incidence of factors (in travel experienced by particular sets of vehicles or road users) that are associated with accidents. By comparing their incidence in travel with their incidence in accidents, those factors more and less likely to be implicated in accidents may be identified. Distance travelled is the most common measure of exposure. Number of trips is another important exposure measure. Exposure factors may include almost any driver, vehicle or environmental variable. Examples are driver age, fit of anti-lock brakes and road class.

There are several types of exposure data and as many methods of collecting them. For present purposes, it is sufficient to consider two different but complementary methods that are used in collecting mass exposure data. Classified traffic counts use automatic methods of varying degrees of complexity and discrimination to record the frequencies with which specified classes of vehicles appear in the traffic stream at each of a relatively large number of sites on a road network. They can provide essentially continuous data on a few basic vehicular and environmental variables. Provided that the road segments on which the sites are located constitute a probability sample of the network they are intended to represent, estimates of the distances travelled by each vehicle class on that network may be derived from the counts. Travel surveys assemble more detailed information about the travel of a sample of vehicles or road users by direct methods. These surveys can address most driver, vehicle and environmental variables in detail. The method used depends on the specific vehicle or road user considered. The vehicles or road users surveyed preferably constitute a probability sample drawn from the population of interest. To be of maximum use, a travel survey must use definitions of variables that are consistent with those used in accident data and in classified traffic counts.

In principle, exposure data needs might be met entirely by appropriately designed travel surveys. In practice, such surveys are expensive and the potential biases introduced by non-response always leave some doubt as to their representativeness. They are therefore normally done only periodically to supplement traffic counts by providing data that cannot be obtained by automatic methods, particularly on vehicle occupancy. Those data can be used with the data from traffic counts to estimate trends in occupant exposure until the next travel survey is undertaken.

### Special Studies

Regardless of the scope of any continuing program of exposure and accident data collection that might be envisaged, there will continue to be a need to undertake special studies to answer specific questions. By their nature, it is difficult to deal with such studies generically since all that they may have in common is that they are not adequately covered by the basic data systems. Special studies of accidents, exposure and risk have been excluded from consideration herein.

### Applications of Accident and Exposure Data

The principal use of accident and exposure data is in the estimation of risk. There are, however, a wide range of specific situations in which risk estimates are desirable or essential. A few of the more important are outlined here.

Accident and fatality trends are of continuing public and political interest but provide only a crude measure of progress in road safety. Regardless of whether those trends are rising, stable or falling, little can be said about their significance in the absence of information on the concomitant trends in travel. The existing sources of information on the amounts and types of road travel in Canada are entirely inadequate as a basis for interpreting accident trends.

Estimates of the risk associated with particular exposure factors are essential for problem identification. A high incidence of a particular factor or set of factors in accidents is not a sufficient basis for identifying a road safety problem, as is evident from the fact that most accidents occur on dry roads in broad daylight. While many factors can readily be identified as harmful, the influence of others can only be inferred by reference to their incidence in travel generally. Given that a problem has been identified, prospective and retrospective estimates of the effectiveness of accident countermeasures are facilitated if consistent exposure and accident data are available.

A further major application of accident and exposure information is in modelling the safety and energy consumption of the road transportation system. The principal use of such models is to examine the effects of expected or possible future trends in, for example, the characteristics of the vehicle fleet or the demographic characteristics of the driving population. One example of such a model made use of data from the 1978-79 National Driving Survey, the TRAID data base and other information. It showed the effects on injuries, fatalities and aggregate fuel consumption of several scenarios involving varying amounts of travel by very small, light urban vehicles. Since, all other things being equal, accidents vary as a function of travel, it is virtually impossible to construct such a model unless the travel patterns underlying current accident statistics are adequately defined.

Several other, somewhat related, applications of consistent accident and exposure data could be described, but the foregoing should suffice to indicate both the need for, and the potential of, such data.

## 6.2 DEVELOPMENT OF ACCIDENT COUNTERMEASURES

Highway accidents are caused by physical sets of circumstances. A certain accident would not occur if a certain set of circumstances could be eliminated.

What are those circumstances that must be eliminated? Although this is the fundamental problem in countermeasure development, further problems presented in Table 10 aggravate the situation.

## TABLE 10

## DIFFICULTIES ASSOCIATED WITH DEVELOPMENT OF ACCIDENT COUNTERMEASURES

1. There is no single circumstance that causes accidents, but rather a multitude of circumstances.
2. Some circumstances are likely to occur more frequently than others.
3. A mutlitude of circumstances are likely to interact, so if only one circumstance exists, it may not be sufficient to cause an accident.
4. Not all accidents are of the same severity.
5. Limited resources prevent the development of countermeasures for every circumstance.

There are several traditional approaches used to identify countermeasures, as follows.

### Proof of Hypothesis

In this approach, a set of circumstances is assumed to exist, and accident data is examined to confirm the hypothesis. This method relies on the skill of investigators to form a reasonable hypothesis, and their ability to prove the theory based on available data. This method, however, does not lend itself to ranking the various hypotheses.

### In-Depth Case Control Investigations

This method involves a detailed examination of specific accident case types. It supposes that technical expertise and detailed analysis will lead to the identification of circumstances that caused a specific case-study accident, and other accidents of the same type. This approach is very expensive, costing approximately $10,000 per case study, and it does not lend itself to the identification of interactive factors.

A less expensive variation of this approach is a site-control study, which suggests that causal factors are associated with a specific location and time. Thus by studying vehicles passing the accident site one week later, causal factors may be identified.

### Statistical Analysis

This method analyzes large data banks of accident information in the hope that a pattern or prevalent circumstance will emerge. Because the analysis does not take exposure into consideration, the statistical analysis method cannot determine accident rates.

While each of these approaches serves a useful purpose and provides specific information, none lends itself to the efficient development of effective countermeasures. What is needed is a systematic approach which allows a multivariable statistical analysis to link objective data obtained from level one accident reports to truck use data. The results of this statistical analysis can identify causal factors, and combinations of causal factors that may have greater influence on accident rates than factors considered individually. This analysis may also allow determination of frequency of accidents by causal factor(s). The available resources for countermeasure development can then be efficiently assigned to the primary causes. Some possible benefits of systematic and effective use of a good accident and exposure data base are listed in Table 11.

## TABLE 11

## POSSIBLE BENEFITS OF PROPER USE OF A SOUND ACCIDENT AND EXPOSURE DATA BASE

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1. Greater responsiveness to the safety needs of the travelling public.
2. Allocation of limited resources based on need.
3. R&D safety activities focused on accident prevention.
4. A basis for monitoring the effects of economic regulatory reform to ensure that it does not compromise safety.
5. A means of monitoring safety issues which flow from the National Transportation Act.
6. A means for the National Transportation Agency to monitor the implementation of the Motor Vehicle Transport Act.
7. Data for cost benefit analysis needed by the Road Safety Branch for proposing regulatory countermeasures.
8. Data for public dissemination on safety issues.
9. A means of monitoring the effectiveness of the Dangerous Goods Act and related enforcement activities.
10. A support for corporate pavement and bridge procurement, and operational objectives.
11. A basis for cooperative federal-provincial awareness campaigns on national safety issues.

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### 6.3 CANADIAN SITUATION

Transport Canada has set a priority on ensuring that a safe and efficient transportation system exists for public and industrial use, and has identified highway freight transport as a specific area for program development. Transport Canada's Road Safety Branch has found that heavy commercial vehicles were involved in 400 to 460 deaths each year between 1984 and 1986. An additional 9 000 to 9 700 personal injuries are also attributed to accidents involving heavy trucks during that time period. Various issues associated with data collection and analysis in Canada are described in the following.

**Registration Data**

In Canada, vehicle registration and highway accident reporting are vested in the provincial and territorial governments.

The data requirements for each province and territory have evolved somewhat independently of national considerations. They are likely to be deeply embedded in the massive computerized data banks used to support a jurisdiction's vehicle licencing activities or provincial insurance corporations. Differences in classifications of vehicle body style and weight pose problems, and the provincial registration data cannot be assumed to be accurate or up to date, particularly with respect to commercial vehicles. Following are some examples of difficulties associated with vehicle regulation data.

There are hundreds, perhaps thousands, of commercial trailer manufacturers and commercial trailer modification shops that deal in very low volume. Trailers from these manufacturers are frequently registered as "homebuilt" or have incorrectly assembled VIN codes. Should an existing trailer be modified, perhaps with a different body style or by the installation of additional axles, the original registration data on file with the province or territory is rarely corrected. While standard body codes have been developed for the New Vehicle Identification System (NVIS), many jurisdictions do not verify or record the coded data. If the code is recorded, the trailer manufacturer's key to interpreting the code is rarely available. There is also a problem with power units that are rebuilt using glider kits (chassis or shells). Some jurisdictions register these according to the VIN of the original powertrain, while others record them as new vehicles under the glider's VIN.

Another problem is the matching of vehicle number plates to vehicles. It is a widespread practice to switch trailer plates among trailers within an owner's fleet, or to use trailer floater plates, Single Trip Permits or Quarterly Permits on unregistered trailers. Account must also be taken for United States-based units temporarily operating in Canada. Finally, some jurisdictions issue multi-year number plates to trailers, and do not purge their files of obsolete data. Thus the registration files may include significant numbers of trailers that are not in service and have not been in service in the jurisdiction for many years.

### Exposure Data

While most vehicle registration data files do not contain odometer readings, provincial and territorial governments do maintain accumulated fleet mileage data on interprovincial private and for-hire carriers for the purpose of prorating fuel, licence and sales taxes. The data elements have been standardized to a degree as a result of the Canadian Agreement on Vehicle Registration (CAVR) and Single Application Vehicle Registration (SAVR) initiatives. Further standardization in data codes is likely to occur with the implementation of the National Safety Code's interjurisdictional data links.

Other exposure data sources, which may or may not be available according to jurisdictional practices, are presented in Table 12.

TABLE 12

**POTENTIAL EXPOSURE DATA SOURCES**

1. Permits for oversized or overloaded vehicles, issued from a central office or weigh scales, typically contain very detailed descriptions of the vehicle configuration, axle spacing, axle loading, load and route to be followed.
2. Vehicle classification studies conducted by the ministry responsible for highway planning.
3. Weigh-in-motion scale facilities typically have the capability to classify vehicles according to axle placement, axle weight, number of axles and gross vehicle weight.
4. Gasoline, diesel and alternative fuel sales records.
5. Trucking associations within the various jurisdictions.
6. Driver logs used in enforcement of the National Safety Code, to determine hours of service.

The needs for exposure data are vigorously debated within Transport Canada. The value and utility of the following three data bases, described in detail in Tables 13, 14 and 15 respectively, appear to be undisputed:

1. national classified traffic counting data;
2. periodic national surveys of travel by light-duty vehicles; and
3. periodic national surveys of travel by heavy trucks.

Explicitly excluded from the group are the Level II accident studies of light trucks and vans and passenger cars, the utility of which remains to be demonstrated. Also excluded are various other enhanced Level I and Level II files (such as Extended Ontario Accident File, Air-Braked Vehicle File, Fully Restrained Occupant Study) that have proven invaluable in the past.

### Accident Data

All Canadian jurisdictions require that vehicular accidents involving injury or death be reported, as well as those producing property damage above specified monetary levels. Three of the principal reporting differences which currently exist between jurisdictions are: the time frame following an accident during which a death may be attributed to the accident, the definitions, and the level of property damage required for reporting.

There are also jurisdictional differences in the requirement to record accident data. Although jurisdictions issue specific guidelines as to which accidents must be reported, guidelines respecting the completion of an accident report by a police officer are not clear. These guidelines also frequently vary within a jurisdiction due to the presence of different enforcement agencies (e.g. municipal, provincial and federal). In some cases, the accident form is completed by a person other than the attending police officer.

When compared internationally, jurisdictional accident report forms are of a good standard and progress has been made in Canada towards a uniform, nationally acceptable accident report form.

The accident report form has been designed to deal with passenger-car accidents, and typically includes data concerning identification of the vehicles, the vehicle occupants and their injuries, the location and time of the accident, the weather conditions and the movements of the vehicles immediately before the accident. When an accident involves a commercial vehicle, information relating to the vehicle configuration, its load, the type of roadway and the driver's experience is not included. Furthermore, a combination vehicle, such as a tractor-semitrailer or a B train, will frequently be identified solely by reference to the number plate or registration or licence of the power unit. Accident reports frequently do not identify trailers unless there is a specific reason to do so.

As a result of the problems in assembling reliable accident data, Transport Canada has initiated a Traffic Accident Information Database (TRAID) described in general form in Table 16. It has also established 10 Multidisciplinary Accident Investigation (MDAI) teams at several universities across Canada.

### Transport System Efficiency Data

While a reasonable amount of detail is available on the construction standards for roadways within the national highway systems, no data sources are known which quantitatively measure the freight transport efficiency of various highway routes. Most vehicle operators are able to accurately pinpoint bottlenecks within the roadway network, however, and to provide qualitative data respecting route efficiency.

## TABLE 13

## PROPOSED EXPOSURE DATA BASE DESCRIPTION FOR NATIONAL CLASSIFIED TRAFFIC COUNTING DATA

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**DATA TYPE**

Exposure.

**DATA COLLECTION METHOD**

Classified traffic counts.

**TARGET POPULATION**

All classes of motor vehicles.

**GEOGRAPHICAL REGION**

All provinces.

**PERIODICITY**

Continuous.

**VARIABLES RECORDED**

Vehicle class, road class and jurisdiction, date, time.

**SAMPLING PROCEDURE**

Stratified, multi-stage, replicated probability sample of sites, times and dates.

**PRIMARY APPLICATIONS**

Explain influence of annual and seasonal trends in vehicle travel on accident trends. Estimate accident rates of principal vehicle classes.

**SECONDARY APPLICATIONS**

Input to explanatory models of traffic accident production, estimates of average fuel consumption by vehicle class, estimates of aggregate pollutant emissions.

**CURRENT STATUS**

Developing methodology for national counting network in cooperation with provincial and municipal governments.

**REMARKS**

Classified traffic counts provide the most economical means of obtaining data on travel by specified vehicle classes. Used in conjunction with the data obtainable from the more costly periodic travel surveys (described earlier), they can provide a fairly complete picture of the exposure of both occupants and vehicles.

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An economic report prepared by IBI Group Inc. in support of the Roads and Transportation Association of Canada (RTAC) weights and dimensions study did take a detailed look at vehicle efficiency vs. vehicle configuration, and at modal shifts. Following ratification of the Memorandum of Understanding (MOU) on Interprovincial Weight and Dimensions, a review of these economic assessments is warranted, especially since each province has exceeded the MOU standards to various degrees, and western Canada has uniformly adopted a longer semitrailer and overall vehicle length.

## TABLE 14

## PROPOSED EXPOSURE DATA BASE DESCRIPTION FOR PERIODIC NATIONAL SURVEYS OF TRAVEL BY LIGHT-DUTY VEHICLES

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**DATA TYPE**

Exposure.

**DATA COLLECTION METHOD**

Driver and vehicle log.

**TARGET POPULATION**

Light-duty motor vehicles and drivers.

**GEOGRAPHICAL REGION**

All provinces.

**PERIODICITY**

Every 5 years.

**VARIABLES RECORDED**

Vehicle identification number; vehicle type; driver age, gender and other variables; vehicle occupancy; trip purpose; trip length; start time and date; end time and date; distribution of travel by road class, lighting and weather conditions.

**SAMPLING PROCEDURE**

Stratified, multi-stage probability sample of drivers and vehicles.

**PRIMARY OUTPUTS**

Estimates with known reliability of total vehicle or occupant travel by vehicle type by province. Distribution of travel by vehicle type by road class by time of day. Distributions of trip lengths and average speeds.

**APPLICATIONS**

With accident data, estimate driver and occupant risks under various conditions. Input to vehicle fleet fuel consumption models (trip speed distributions). Input to explanatory models of traffic accident production, estimates of average fuel consumption by vehicle class, estimates of aggregate pollutant emissions.

**CURRENT STATUS**

Driver-based survey conducted only once, in 1978-79. Data known to be significantly out of date in certain respects.

**REMARKS**

Travel surveys provide exposure data that cannot be obtained from classified traffic counts, in particular on occupant and trip characteristics.

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### Transport System Responsiveness Data

Annual origin-destination surveys are conducted by Statistics Canada and published in its catalogue #53-222 (1). Of particular interest to the federal operational and procurement initiatives are the effects of the RTAC weights and dimensions study on interprovincial freight transport, and the effects of the free trade agreement on international transport. The Statistics

## TABLE 15

## PROPOSED EXPOSURE DATA BASE DESCRIPTION FOR PERIODIC NATIONAL SURVEYS OF TRAVEL BY HEAVY TRUCKS

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**DATA TYPE**

Exposure.

**DATA COLLECTION METHOD**

Prearranged telephone interview with dispatcher or equivalent person. Each vehicle in sample logged for 24 hours, four times annually.

**TARGET POPULATION**

Unit trucks weighing more than 4.5 tonnes and road tractors.

**GEOGRAPHICAL REGION**

All provinces.

**PERIODICITY**

Every 5 years.

**VARIABLES RECORDED**

Vehicle identification number, vehicle type, driver age and gender, vehicle occupancy, number of trailers, hitch type, vehicle route, vehicle loading as function of distance, times of key events.

**SAMPLING PROCEDURE**

Complex probability sample of vehicles.

**PRIMARY OUTPUTS**

Estimates with known reliability of total travel by vehicle configuration by province. Distributions of travel by vehicle configuration by road class, time of day, loading condition, etc. Distributions of average trip speeds.

**APPLICATIONS**

With accident data, estimate relative risks of operating heavy trucks under various driving conditions. Estimate accident rates for heavy-duty vehicle classes. Analyse exposure variables as function of class of carrier. Input to vehicle fleet fuel consumption models (trip speed distributions). Input to explanatory models of traffic accident production, estimates of average fuel consumption by vehicle class, estimates of aggregate pollutant emissions.

**CURRENT STATUS**

No current or earlier action.

**REMARKS**

Travel surveys provide exposure data that cannot be obtained from classified traffic counts, in particular on driver, company and trip characteristics.

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Canada 1986 Trucking in Canada survey shows that over 45% of all Canada-United States commodity traffic is with the North Central states. More than 65% of the exports and 70% of the imports between Canada and those states are transported by truck.

## 6.4 UNITED STATES EXPERIENCE

The U.S. Department of Transport has compiled three accident data files: the Fatal Accident Reporting System (FARS), which provides a summary of all fatal accidents; the Office of Motor Carrier Safety (OMCS) file, which is assembled from independent accident reports submitted by every interstate motor carrier involved in an accident; and the National Accident Sampling System (NASS), which is compiled from police reports. Since 1979, the University of Michigan Transportation Research Institute (UMTRI) has collected, reconciled and collaborated the FARS and OMCS files for heavy trucks (over 4 535 kg) to create a fourth file, Trucks Involved in Fatal Accidents (TIFA). Approximately 5 000 accidents per year are added to the file. Because the TIFA file has been extensively checked for accuracy and has very little missing data, it is believed to contain the most accurate data of this type available for American interstate carriers.

Between 1985 and 1987, UMTRI conducted a comprehensive survey of 5 000 truck owners, on a quarterly basis, for the purpose of quantifying the exposure of large trucks to accident risks. The data has been assembled into a Truck Inventory and Use Survey (TIUS) file. By comparing the TIFA and TIUS files, fatal accident rates on federally regulated highways can be determined by vehicle type, road class, etc. This has not yet been done in depth, however, due to lack of fiscal support for the project. It should also be recognized that the exposure data relates only to one year of operation (1986), thus making it impossible to monitor changes in exposure rates with time.

While vehicle configurations, highway geometry and vehicle use differ between Canada and the United States, the systematic approach adopted by UMTRI to link accident frequency and exposure appears to be applicable.

## 6.5 AUSTRALIAN EXPERIENCE

The Australian Bureau of Statistics periodically collects limited data on heavy truck usage, but individual states are responsible for collecting accident data. While cooperative efforts between the states and the Commonwealth has improved the quality of the data, further improvements in the uniformity of accident reporting requirements and definitions are being sought. The Commonwealth Government Federal Office of Road Safety has been assembling a National Fatal Accident File since 1980, and is currently developing a National Casualty File.

The most accurate Australian data currently available linking accident rates, vehicle configurations and exposure is a 1984 report commissioned by the Commonwealth Government into the road freight industry. The report, entitled "National Road Freight Industry Inquiry," pertains to industry activities in the preceding year.

## 6.6 EUROPEAN EXPERIENCE

Most European members of the Organization for Economic cooperation and Development (OECD) have conducted a number of in-depth and statistical accident analyses, but few of these consider exposure. The quality of the collective data representing accident rates in the whole of Europe suffers due to considerable differences between countries in accident reporting requirements, vehicle classification, codes and definitions.

The OECD has published its recommendations concerning the contents of accident reports in the Road Transport Research Report entitled "Road Accidents: On-Site Investigations." This publication also summarizes the accident research projects undertaken by various member countries.

## TABLE 16

## ACCIDENT DATA BASE DESCRIPTION

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**DATA TYPE**

Accidents.

**DATA COLLECTION METHOD**

Data tapes and documentation provided by provincial governments.

**TARGET POPULATION**

All vehicle classes.

**GEOGRAPHICAL REGION**

All provinces and territories.

**PERIODICITY**

Annual.

**VARIABLES RECORDED**

Basic data on involved vehicles, vehicle occupants, accident location and environmental conditions. Data on immediate material and personal consequences of accident. All data subject to limitations imposed by individual provincial accident reporting forms and procedures.

**SAMPLING PROCEDURE**

Nominally a census of legally reportable accidents in Canada.

**PRIMARY OUTPUTS**

Annual estimates of numbers of fatal and injury-producing accidents by province, numbers of involved vehicles by type, numbers of casualties by victim class and injury severity (fatal or non-fatal).

**APPLICATIONS**

Provide principal current index of road safety, i.e. annual fatality total. With exposure data, calculate accident rates by severity by vehicle class. Calculate relative risks of travel for different vehicle classes. Provide initial estimates of potential for specific accident countermeasures. Evaluate effectiveness of implemented countermeasures. Input to explanatory models of traffic accident production.

**CURRENT STATUS**

TRAID (Traffic Accident Information Database) has existed under continuous development since 1973-74.

**REMARKS**

For purposes of countermeasure evaluation and development and for various research purposes, the ability to identify the make and model of an involved vehicle would greatly increase the utility of the data base. TRAID is the principal existing accident data base for research, countermeasure development and public information on road safety in Canada.

## 6.7 POTENTIAL R&D OPPORTUNITIES

To evaluate exposure, it is necessary to have measures of travel (with consistent definitions) which are then linked to the accident counts for a given period. Vehicle configurations must be identified to obtain meaningful results that permit useful analysis and decision making. To this end, it is important to have classification equipment that is reliable, provides the minimum required data in a convenient format for easy handling, and is low cost. Questions regarding storage of the massive amount of collected data, and how to analyse the data, should also be considered.

The basic requirements for a "national sampling system" are judged to be the following.

1. A system of permanent counting stations (PCS) would operate 24 hours per day. The number and locations of these would be selected through analysis of the national road network. A representative cross-section of this network would need to be monitored as required by the data accuracy specification.
2. A proper sampling framework would need to be established to permit congruous operation of portable and permanent counting and classification systems to address effects of seasonal changes, weather, changes in vehicle mix, etc. The portable units would permit adjustments to be made to weighting factors used with the permanent counting stations to give more accurate short-term results and to follow longer-term trends.

The framework for implementing a "national sampling design" should as a minimum include one or two provinces initially, which would then be expanded to include all as required.

There are opportunities for exposure data innovation in Canada. There has been rapid progress in data collection capabilities as a result of technological change. Many provinces (such as Quebec, Ontario and Saskatchewan) are looking at the possibility of expanding and updating their systems. It is important that there be effective coordination of all efforts to facilitate further cooperation in the future and the implementation of a "national sampling system". The "national sampling design" should reflect the country's present data collection capabilities and the provinces' future plans. The implementation of a national system will likely involve negotiation with the provinces for specific requirements that go beyond provincial concerns.

To support the accident and exposure data collection requirements, there is a further need to develop a national system for identifying a position on the national highway system. The required precision would be prescribed by accident and exposure data needs.

The overall need is to develop more complete and meaningful heavy truck exposure and accident data. Potential areas of investigation and development include the following, which are described in detail in Tables 17 and 18.

1. Available Data Survey
2. Data Needs Survey
3. Accident Location Survey
4. Technology Transfer
5. Accident Data Collection
6. Exposure Data Collection
7. Data Analysis

## TABLE 17

## POTENTIAL AREAS FOR INCREASED COLLECTION OF HEAVY TRUCK EXPOSURE AND ACCIDENT DATA

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1. **AVAILABLE DATA SURVEY**
    - a. Identify existing data sources.
    - b. Determine accuracy of existing data sources.
    - c. Develop mechanisms to identify and correct data errors.
    - d. Identify mechanisms to obtain missing data elements.
    - e. Estimate data survey costs.
2. **DATA NEEDS SURVEY**
    - a. Identify appropriate measures of performance for evaluations supporting corporate safety, efficiency and responsiveness objectives.
    - b. Identify quantitative measures to gauge operational, regulatory and procurement initiatives that have potential to achieve corporate objectives.
    - c. Identify specific goal, and minimum acceptable statistical significance, to be achieved by data analysis.
    - d. Identify preferred survey frequency.
    - e. Identify specific data required to satisfy corporate-provincial-industrial data analysis needs.
3. **ACCIDENT LOCATION SURVEY**
    - a. Develop national systems for identifying a position on the National Highway System within a precision prescribed by the Data Needs Survey.
    - b. Prepare a program for implementing the highway location identification system.
4. **TECHNOLOGY TRANSFER**
    - a. Identify and develop Canadian expertise in conducting multivariant surveys.

## TABLE 18

## POTENTIAL AREAS FOR INCREASED COLLECTION OF HEAVY TRUCK EXPOSURE AND ACCIDENT DATA

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5. **ACCIDENT DATA COLLECTION**
    - a. Publish standard guidelines and practices for police officers to follow when completing level 1 accident reports (note: these may be unique to each region as accident report forms are not uniform across Canada).
    - b. Collect, verify and correct accident data.
    - c. Investigate methods for automating accident data collection.
6. **EXPOSURE DATA COLLECTION**
    - a. Establish exposure and classification data needs, and associated variables to be considered.
    - b. Prepare terms of reference for a national sampling design.
    - c. Undertake a national sampling design feasibility study, including sampling sites, technologies, costs, schedule, manpower requirements, etc., associated with implementation of sampling system.
    - d. Develop criteria for evaluation and selection of counting and classification equipment, examine technology options and make recommendations on equipment to be field tested.
    - e. Field-test potentially acceptable counting and classification technologies for adequacy, and recommend optimal equipment.
    - f. Undertake an options analysis, examining alternatives to the national sampling system, to identify the potentially most desirable and achievable option.
    - g. Fully implement the selected option.
7. **DATA ANALYSIS**
    - a. Provide data and develop enabling software in accordance with established operational, regulatory and procurement goals.
    - b. Analyze accuracy and sensitivity of survey results to determine if original data needs specifications require change.
    - c. Recommend changes for future surveys.
    - d. Publish report on methodology and recommendations.
    - e. Present findings at a symposium on truck safety.

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## 7. TECHNOLOGY ASSESSMENT AND DIFFUSION

Global efforts are underway to improve the safety and productivity of both highway freight vehicles and their infrastructure. In Europe, the EUREKA project is co-ordinating some 165 separate projects relating to on-board electronic communications, information and navigation systems. In the United States, the PATH (Program on Advanced Technology for the Highway) project is considering active traffic control mechanisms, the SHRP project is looking at extending pavement and structure life while reducing maintenance costs, and the HELP (Heavy Vehicle Electronic Licence Plate) and CRESENT projects are studying automatic vehicle identification and weigh-in-motion technologies. Australia's Road Research Board is looking at improving the roll stability of commercial vehicles by matching vehicle suspension parameters.

Canadian highway freight industries must incorporate the latest research technology in the most efficient and effective manner possible. Since a large proportion of highway technological advancements occur offshore, the identification and integration of valuable foreign technology is essential.

Canadian research into highway freight transport technologies is fragmented and often lacks international scope. Researchers have also had difficulty disseminating their findings to companies seeking solutions to existing and potential problems.

Researchers, by their nature, have great depth of knowledge in narrow fields. While this depth of knowledge allows advances in fundamental research, it stifles progress in long-term and sector-directed programs. For example, in Canada, pavement and bridge engineers have not collaborated in setting the overall structural design capacity of highway projects, tractor and trailer designers promote non-integrated concepts, vehicle safety specialists consider dynamic stability independently of roadway geometrics, highway construction and highway design engineers have not collaborated to optimize ride qualities, and so forth. This fragmented approach typically results in research projects that are narrow in scope and do not exploit resources available in related fields. Nonetheless, Canadian researchers have made significant contributions to highway freight transport technologies. A means must be found to promote the work done by Canadian agencies within the global research community.

The benefits of an integrated approach to vehicle research and technology transfer were amply demonstrated by the RTAC/CCMTA weights and dimensions study. Visiting researchers helped develop Canadian expertise in vehicle dynamics, which was then supplemented by experts in pavement and bridge effects, traffic stream effects, economics, implementation and enforcement.

A summary look at research and development in various Western countries, including Canada, and on-going R&D work with potential effects in Canada, are reviewed in the following.

### 7.1 CANADA

In Canada, there are a number of organizations and world-class experts involved with highway transport technologies.

The organizations generally considered to be involved with these technologies are the following.

**Roads and Transportation Association of Canada (RTAC)**

Founded in 1914 as the Canadian Good Roads Association, this organization first concerned itself with roads and road transportation. During the 1950s it engaged in technical activities and, by the late 1960s, it had developed a broader range of interests. In 1970 it adopted its present name. In 1983 a new set of bylaws was adopted, setting out the following aims and objectives.

1. Provide an effective forum for:
    a. interface between the various modes of transportation; and
    b. interrelationship between and among governments, the academic community and the various components of the transportation industry.
2. Provide programs and services in the field of transportation, with particular emphasis on road and transit systems, and including:
    a. technical research and information dissemination; and
    b. improvement of transportation efficiency and safety.

RTAC maintains an extensive committee structure to ensure that adequate attention is paid to all the areas in its field of interest. The most significant of these committees are described in Table 19.

### National Research Council

The National Research Council (NRC) is one of the most effective instruments the federal government has to address technology needs that are relevant to the Canadian economy. The NRC objective is to create and to acquire scientific, engineering and technical knowledge and information. It also promotes the use of this knowledge and information for economic, regional and social development.

The NRC is currently considering the establishment of an Institute of Road Vehicles Dynamics as part of its Transportation Research and Development Program. The institute would build on the existing NRC Road Vehicle Research Program in the Vehicle Dynamics Laboratory. With much of the capital infrastructure already in place, including buildings and test rigs, the principal task would be to establish a nucleus of experts and support staff. This group would develop a research and service network in cooperation with federal and provincial governments, universities and the industrial sector.

### Transportation Technology and Energy (TT&E) branch of the Ontario Ministry of Transportation

The TT&E branch of the Ontario Ministry of Transportation has a mandate to increase the safety and productivity of the trucking industry. It does this by conducting research into the stability and control of heavy commercial vehicles, providing technical expertise to the safety and regulation program in the development of vehicle regulations, recognizing the need for preservation of the infrastructure, assisting industry in developing new products and participating in joint projects of common interest with other agencies. TT&E's goal is to play a leadership role in heavy vehicle research and to be a focal point in joint programs and a consultant on heavy vehicle technical matters.

Other Canadian agencies that have established themselves as leaders in their particular field of endeavor are: the Road Safety and Motor Vehicle Regulation branch of Transport Canada, with respect to vehicle safety and defect investigation; and the Alberta Research Council, with respect to the effect of axle loads on asphaltic pavements.

## TABLE 19
## SEVERAL KEY RTAC COMMITTEES

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**TECHNICAL COMMITTEES**

These are groups of specialists who meet to discuss technical problems. They also sponsor workshop sessions at the RTAC annual conference, for the presentation of papers and discussion of new developments in their area of interest.

**PROJECT COMMITTEES**

These committees carry out research or development activities, or organize specialized conferences on specific technical subjects. Their efforts usually result in publications.

**ADVISORY COMMITTEES**

These groups help to oversee research and development projects contracted out to consultants. As with project committees, the results of this work are usually published.

**COUNCIL ON HIGHWAY TRANSPORTATION RESEARCH AND DEVELOPMENT (CHTRD)**

This council includes representatives from the federal and provincial governments and from industry associations. A major role of the council is to streamline technology transfer from the R&D sector to the user. Its responsibilities include research planning, priority setting, funding, coordination and information gathering and dissemination. The council publishes and updates inventories of research activities currently underway in Canada, acts as the agency responsible for providing Canadian research data to the International Road Research Documentation (IRRD) data bank, and maintains liaison with the U.S. Transportation Research Information Service (TRIS). It also co-represents Canada on the Organization for Economic cooperation and Development (OECD) Road Transport Research Program Steering Committee, and on the Select Committee on Research of the American Association of State Highway and Transportation Officials (AASHTO).

**COUNCIL ON UNIFORM TRAFFIC CONTROL DEVICES FOR CANADA**

This council is jointly sponsored by RTAC and the Institute of Transportation Engineers. It is responsible for developing national standards in the fields of traffic signs, signals and markings. It publishes information on these national standards and encourages their adoption by the various jurisdictions in Canada.

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### 7.2 EUROPE

Nineteen of the twenty-four members of the Organization for Economic cooperation and Development (OECD) are European. (Canada, the United States, Japan and Australia are the non-European members.) The OECD was formed in the late 1960s because member jurisdictions recognized the economic importance of highway freight transport as an intermediate consumer. All member countries place major emphasis on the study of the effects of heavy freight vehicles and new freight transportation strategies. Some initiatives completed by the OECD to date are listed in Table 20.

In 1985, a Conference of Ministers for 17 European countries and Members of the Commissions of the European Communities established EUREKA, with the objective of raising the productivity and competitiveness of Europe's industries and national economies in the world market. EUREKA hopes to accomplish this through closer cooperation among enterprises and research institutes in the field of advanced technologies. EUREKA comprises some 165 projects, including CARMINAT, PROMETHEUS, DEMETER, EUROPUS and TELE ATLAS. Short descriptions of some of the transportation-related projects are provided in Table 21.

TABLE 20

**SEVERAL COMPLETED OECD INITIATIVES**

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1972 — Accelerated methods of life-testing pavements.
1975 — Resistance of flexible pavements to plastic deformation.
1977 — Symposium on heavy freight vehicles and their effects (Paris).
1979 — Evaluation of load carrying capacity of bridges.
1980 — Management of urban freight distribution.
1983 — Effects of heavy freight vehicles.
1983 — Bridge rehabilitation and strengthening.
1983 — Traffic capacity of major routes.
1984 — Integrated road safety programs.
1985 — Full-scale pavement tests.
1985 — Strain measurements in bituminous layers.
1986 — Technological and economic analysis of the role of road freight transport.
1987 — Seminar on freight vehicle overloading and load measurements.
1987 — Symposium on the role of heavy freight vehicles in traffic accidents (Montreal).

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## 7.3 UNITED STATES

In 1984, the Transportation Research Board (TRB) of the (United States) National Research Council, under the sponsorship of the Federal Highway Administration and with the cooperation of the American Association of State Highway and Transportation Officials (AASHTO), initiated the Strategic Highway Research Program (SHRP). It has focused on asphalt, long-term pavement performance, maintenance effectiveness, ice and snow control and protection of bridge components, cement and concrete. The project was planned to last approximately five years and cost approximately $150 million.

Canada has direct participation in SHRP projects, called C-SHRP. This promotes the transfer of technology between Canada and the United States, and allows Canada to initiate independent but complementary research projects into highway infrastructure problems that are unique to the Canadian environment.

## 7.4 AUSTRALIA

Principal R&D work in Australia is undertaken by the Australia Road Research Board. Their 1975 study on the Economics of Road Vehicle Limitations (ERVL), and the following 1984 study entitled Review of Road Vehicle Limits (RORVL), generated new data on the influence vehicular dimensions and weights have on dynamic stability.

TABLE 21

SUMMARY DESCRIPTION OF SOME TRANSPORTATION-RELATED PROJECTS UNDER THE EUROPEAN EUREKA PROGRAM

**CARMINAT**

This automotive navigational and route guidance system project unites the Phillip's automotive navigation project (CARIN) with both SAGEM's modular information concept based on on-board mass memory (MINERVE) technology, and Renault's automotive information project (ATLAS). The result is a total systems approach for navigation, communication and diagnostics. Preliminary plans call for 52 million ECUs (European Currency Units), including 310 personyears, to be spent developing and testing the prototype of CARMINAT through 1989.

**COST 30**

This project was started in 1984 to examine system approaches, economic potential and standards considerations for "Road/Vehicle Electronic Communications: Electronic Traffic Aids on Major Roads." COST 30 concluded that the most practical approach was to adopt a vehicle-borne navigation aid in combination with area-wide one-way (infrastructure-to-vehicle) communications. International collaboration was needed to identify a suitable broadcasting channel.

**DEMETER**

This project (Digital Electronic Mapping of European Territory) was started in late 1986 to establish a European standard for digitized geographical information. The project proposes to enter commercial production of digital maps in 1989. Plans call for geographical data to be available on compact disks in 1990.

**DRIVE**

Started in 1986, this project (Dedicated Road Safety Systems and Intelligent Vehicles in Europe) has assessed whether information and telecommunication technology can make a major contribution to improvement of road safety. It concluded that standardization and basic research into automatic chauffeuring, machine vision and vehicle control software are of paramount importance.

**PROMETHEUS**

This project started in mid-1986. Its objective is to make road traffic move better, more quickly, more economically and with fewer environmental effects and accidents by the year 2000. The total budget of $400 million will be shared among 13 automotive companies. It will cover work on anti-lock braking, limited slip differential controls, electronic engine controls, instrument design, automatic navigation, vehicle-to-vehicle communications and an electronic accelerator pedal.

Current research centres on matching brake systems between the units of combination vehicles, and on conspicuity, underride and cab strength. Development projects are a continuation of earlier ERVL and RORVL rollover research initiatives. The Australia Road Research Board is now looking at ways to improve vehicle stability by matching truck and trailer suspensions, providing a user's guide, making suspension modifications, lowering the centre of gravity and developing the possibility of early driver feedback to vehicle roll.

## 7.5 POTENTIAL R&D OPPORTUNITIES

### 7.5.1 Technology Assessment

1. Identify and assess potential R&D programs in emerging highway freight transport technologies, such as those listed in Table 22.
2. Promote the establishment of a technical advisory committee within RTAC, consisting of technical experts and industrial representatives. This committee would provide written comment concerning the application of new or ongoing R&D projects to the Canadian highway freight transport industry.
3. Assist industry in identifying and participating in new or existing R&D projects which may effect their operations within the following two to five years.
4. Establish TDC participation in OECD working groups pertaining to highway freight transport technology.

TABLE 22

AREAS OF STUDY FOR POTENTIAL APPLICATION
OF EMERGENT TECHNOLOGIES

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1. Fleet operations and management.
2. Active traffic management.
3. Vehicle location and route information system.
4. Vehicle control applications.
5. Automated vehicle identification.
6. Vehicle, axle and load weight sensing.
7. Highway design, construction and maintenance.
8. Suspension dynamics.
9. Driver performance and driver training technologies.
10. Commercial vehicle safety.
11. Statute compliance.

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### 7.5.2 International Technology Exchange

1. Periodically catalogue status and findings of global R&D activities.
2. Establish focal points within Canada to monitor OECD, EUREKA, PATH, SHRP, CRESENT, HELP and other global research initiatives.

3. Systematically evaluate global research initiatives to determine possible safety and productivity benefits for Canada and Canadian industry.
4. Create and promote a unique identity for Canadian research papers and projects.
5. Expand existing in-house distribution policies for project reports.

### 7.5.3 Coordination of Canadian Research

1. Periodically catalogue Canadian R&D facilities and institutes.
2. Develop a means to promote links between projects and networks among researchers.
3. Organize and establish a formal presentation of research and development project results at an annually held Canadian research symposium.
4. Continue to support RTAC's efforts to schedule and hold world-class symposiums on highway technologies.

### 7.5.4 Emerging Technologies for Traffic Management

Examine emerging computer and communication technologies likely to be applied to traffic management in street control, freeway management, and enforcement, as detailed in Table 23.

### 7.5.5 Emerging Technologies for Vehicle Monitoring and Control

Examine emerging computer, robotic and communications technologies likely to be applied to vehicle monitoring, vehicle control and robotic steering, as detailed in Table 24.

### 7.5.6 Interprovincial Communications and Systems Interfacing

Identify candidate protocols for interfacing provincial vehicle and driver records, transport communication technologies related to vehicle control and traffic management, and transport navigation and vehicle location technologies.

## TABLE 23

## POTENTIAL APPLICATIONS OF EMERGING COMPUTER AND COMMUNICATION TECHNOLOGIES TO TRAFFIC MANAGEMENT

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1. **STREET CONTROL**
    - a. One-way streets, reversible streets and/or lanes and turn restrictions.
    - b. Parking restrictions and snow clearance routes and schedules.
    - c. Loading and unloading rules.
    - d. High occupancy vehicle designations.
    - e. Stopping places for violators (directions from freeway, etc.).
    - f. Emergency clearance for toxic spills, fires, chase, storms, etc.
    - g. Event management.
    - h. Transmission of content of electronic signs (destination, etc.).
    - i. Display of prepurchased electronic tokens at parking meter.
2. **FREEWAY MANAGEMENT**
    - a. Incident detection, verification and response, and surveillance and control measures.
    - b. Transmission of:
        - — corridor conditions reports (for requested origin and destination);
        - — ramp and lane closures;
        - — alternative routes and advisory speeds;
        - — pretrip advisory;
        - — average and hour-specific origin and destination travel times; and
        - — suggested alternative departure time.
    - c. Road use pricing by peak and off-peak, and by vehicle type and home base.
    - d. Access control (via vehicle and driver ID transmission).
    - e. Parking availability and rates by type.
    - f. Designated routes for trucks, dangerous goods, snow removal and garbage collection.
3. **ENFORCEMENT**
    - a. Transmission of:
        - — radar and airplane-detected excess speed (and other manoeuvres);
        - — electro-optically detected tailgating;
        - — axle load, route and hour violations; and
        - — pull over and stop command.
    - b. Accident reconstruction (i.e. short term memory (black box)) for:
        - — driving manoeuvres and speed; and
        - — lane positioning.
    - c. Enforcement and apprehension (also provides electronic record for courts) of:
        - — violator vehicles; and
        - — stolen vehicles.
    - d. Accumulation of:
        - — special merit points; and
        - — demerit and/or violation points.

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## TABLE 24

## POTENTIAL APPLICATIONS OF EMERGING COMPUTER, ROBOTIC AND COMMUNICATION TECHNOLOGIES TO VEHICLE MONITORING AND CONTROL

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1. **VEHICLE MONITORING**
   a. Status of vehicle systems:
      - diagnostic displays;
      - anticipated failure alert; and
      - response-to-failure tips.

   b. Maintenance:
      - tips (e.g. jump start steps to protect electronics);
      - customized work order processing for preventive maintenance;
      - warranty expiration alerts; and
      - tow vehicle availability and rates.

   c. Operations statistics for each driver (hours and distance and level of fuel).

   d. Manner-of-use record for each driver (with exception alerts) for speeds (actual and compared to limits), idling and abrupt handling.

2. **VEHICLE CONTROL**
   a. Collision avoidance systems:
      - minimum gap alert;
      - weather and surface friction alert; and
      - suggested maximum speeds.

   b. Rear view display and ultrasonic obstacle warning for backing up.

   c. Nighttime infrared forward imaging system (obstruction alert).

   d. Perimeter vision and scanning (for extra long and wide loads).

   e. Driver alertness monitoring (e.g. number of steering corrections) and alert ("snooze alert") and automatic limitation of vehicle response.

   f. On-board physiological monitoring.

   g. Anti-theft device (starting by key code, voice print or smart card, with automatic transmission of tracking signal and disabling of essential controls).

   h. Comfort:
      - individualized radio station, tape and CD selection; and
      - individualized positioning of seat and windows, and selection of temperature.

3. **ROBOTIC STEERING**
   a. Automatic highways (median lane control):
      - steering function; and
      - accelerator function.

   b. Response to man-made and natural disasters (spills and fires).

   c. Autonomous land vehicles for military operations such as surveillance, reconnaissance, advance columns and mine field clearance.

# 8. VEHICLE TECHNOLOGY RESEARCH

Based on 1985 data, for-hire trucking annually moves more than 162 million tonnes of freight with gross operating revenues exceeding $6.7 billion, or 20 kg for each dollar. In comparison, the railways moved 255 million tonnes with gross operating revenues of $7.6 billion, or 30 kg for each dollar. In spite of the economic advantage enjoyed by rail customers, trucking operations, with door-to-door service, accounted for 31.9% of Canadian freight traffic. By 1995 total freight traffic is expected to increase 18.2%, and truck operations are expected to increase their penetration of the market to 35.1%. These forecasts of increased road transport are supported by current new truck demand, which has pushed all North American heavy truck assembly plants to capacity production.

The transportation gross domestic product (GDP) for all transportation modes currently comprises 4.8% of the total Canadian GDP. This marks a significant improvement since 1961, when transportation GDP was 7% of the total GDP. The 4.8% figure, however, is still almost 50% higher than the comparable figure for the United States.

To remain competitive with American industries, and to increase Canadian penetration of north-south freight traffic, further improvements in road transport productivity must be achieved. The two areas in which these improvements are expected are in regulatory uniformity and transportation electronics. As a measure of the potential benefits in these two areas, the IBI Group Inc. economic report estimated that a gross saving of $160 to 247 million per year could be achieved if vehicle parameters based on vehicle stability and infrastructure effects were uniformly adopted. In a 1986 study (20), TRW concluded that 35 truck electronic systems, which will likely be available within 5 years and achieve 50% of the market within 15 years, could bring about a 7.4% reduction in operating costs and a one-year payback of the $12 000 component costs.

In addition to the productivity gains, truck electronics will play a major role in advancing commercial vehicle safety. Based on available registration and accident data, heavy commercial vehicles are involved in about 3.5% of all reportable accidents and 10% of all road fatalities. The public is concerned about the disproportionate involvement of trucks in fatal accidents, and the public is concerned that in those accidents, an occupant of the other vehicle is usually the fatally injured party.

Equally alarming to commercial vehicle operators are United States and European studies that rate the trucking industry as having an annual fatality rate of 58 deaths per 100 000 workers. This is second only to mining and quarrying, which has a rate of 60 deaths per 100 000 workers. The average industry experiences 11 deaths per 100 000 workers.

Truck safety electronic systems of the future will monitor and record: driver medical and physical condition, providing a feedback alarm for specified unsafe conditions; vehicle dynamic performance, providing the driver with warnings of potentially unsafe conditions; condition of safety-related components and scheduling of maintenance and repair work. It will control the operation of drivetrain, suspension and brake components to optimize performance, preselect routes based on traffic volumes and monitor loading practices.

Commercial vehicle safety issues fall into a wide range of classifications including vehicle stability, dynamic response, aggressiveness, crashworthiness, braking, ergonomics, visibility, maintenance and reliability. In turn, each of these classifications contain multiple subclassifications.

Some current topics in heavy vehicle technology are described in the following.

## 8.1 VEHICLE STABILITY AND DYNAMIC RESPONSE

While the RTAC/CCMTA weights and dimensions study concentrated on the influence size and weight parameters have on vehicle stability and dynamic response, the influence of specific component designs and alternative countermeasures was not fully addressed or understood.

A case in point is the coupling mechanism between trailers. The research study did show that the coupling mechanism has a significant influence on dynamic roll stability and transient off-tracking. The study did not, however, identify those design or performance parameters of coupling mechanisms that contribute to the stability of vehicles and their dynamic response. A separate, limited study into trailer coupling devices is currently being conducted by the National Research Council.

Other areas which need to be addresed are as follows.

### Suspension Mix

Work conducted by the NRC and the Australia Road Research Laboratory has shown that the static and dynamic roll thresholds of vehicle combinations is influenced by the parameters of each axle suspension unit, and the mix of suspension units assembled into the vehicle combination. No recognized standard exists for determining parameter values for suspension systems, and none exists for determining compatibility of suspension systems having different parameters.

### High Stability Suspensions

A typical solution for decreasing vehicle roll is to increase the suspension's spring rate. High spring rates, however, have been shown to have an adverse effect on pavement life. A suspension system having a low spring rate and high resistance to roll would promote both vehicle safety and pavement life, and would reduce damage to cargo that is sensitive to vibration or impact.

### Driver Feedback

In certain commercial vehicle combinations, the driver has little feedback about the behaviour of a distant trailer. If the first trailer is a semitrailer, it influences the feel of the tractor via the 5th wheel, but the second and third trailers may be little more than images in the rearview mirror. Also, rear trailers are indirectly controlled, so rapid corrective action by the driver may be ineffective in preventing dynamic trailer rollover. Not surprisingly, accident data identifies rear trailer rollover as a problem.

### Anti-Jackknife Devices

Jackknife is a highly visible form of tractor-trailer yaw instability primarily associated with tractor rear wheel skidding, although it can also result from trailer swing. The technically preferred and likely most effective solution, as demonstrated by Ontario government testing (27), is skid prevention by improved grip and anti-skid braking systems (ABS). ABS is the subject of public pressure as well as intensive research and development aiming towards early implementation, and is the most likely medium-term solution.

Other devices limit unwanted articulation. They are not cheap. Several are being marketed, but they have achieved little penetration of the overall trucking industry. ABS offers the best chance of improved dynamics at an affordable price. Other anti-jackknife devices may have a place in improving the overall competence of future articulated vehicles, particularly for special applications.

### Improved Safe Operation of "Bobtails"

Tractors are rarely driven "bobtail" (without trailers) for any great distance, and are not prominent in accident statistics. Deeper examination suggests, however, that they are very heavily overinvolved in accidents, particularly fatal accidents. A U.S. estimate is 56 fatal accidents per 100 million km, compared with 5 for complete combinations and 2 for single unit vehicles.

A tractor is designed to carry a trailer, which is essential for dynamic balance. A bobtail feels misleadingly light and agile compared with a loaded vehicle. One of the problems with bobtails, however, is that rear brakes may lock up at very low decelerations. Thus a bobtail is unable to stop as quickly and as stably as a fully laden tractor-trailer.

A bobtail tractor is incompetent compared with other vehicles. Solutions lie in improving the vehicle, and in improving driver discipline in coping with the vehicle's limitations.

Anti-skid braking (ABS) is a practical solution for brake imbalance, and would probably make bobtails fully compatible with other traffic. Another possible solution is to measure whether or not a vehicle is loaded, and change the brake balance accordingly. This could be used with ABS in future brake systems, but it does not have the acceptance necessary for adoption as an interim measure. No easy solution is in the offing for the existing vehicle fleet. This topic is further discussed later in this chapter in the section on "Braking."

The incompetence of a bobtail may be compensated by specially prudent use and driving practice. It is possible that inexperienced drivers may not know their limitations. Awareness programs aimed at carriers and their staff, as well as professional drivers, may be effective.

These comments on bobtails apply equally to other unladen trucks, either combination or single-unit. Bobtails are identifiable. It may not be observed that other trucks involved in accidents are unladen, particularly as, at first glance, it may not seem to be a relevant factor. There is data showing that unladen vehicles are, as would be expected, overinvolved in accidents.

### Axle Grouping

Wide-based tandems and under-belly axles reduce "effective wheelbase" and add "effective overhang," thereby reducing stability and, at the same time, the ability to manoeuvre due to the wide base of unsteered axles. Narrow-based tandems and triple axles with minimum overhang are normal design solutions. Weight and dimension regulations that avoid penalizing these solutions are needed, and should be encouraged.

### Aftermarket Increases in Gross Vehicle Weight Rating

Increasing loads and some "bridge formulae" encourage the addition of axles with characteristics not necessarily matched to the vehicle. Air springs, for example, operate differently from leaf springs. Higher dynamic tire-to-road loadings, with consequent dynamic behaviour effects, can result from a mixture of air springs and leaf springs. Air springs can be controlled intentionally or by omission so that the load on an axle can be inappropriate. Consistent weight and dimension regulations should not favour add-on axles.

### Off-Tracking

Excessive low-speed off-tracking makes the driving task more difficult, limits manoeuverability and may be a factor in pedestrian, bicycle and other low-speed collisions with vehicle sides. Dimension regulations require compromise between low-speed off-tracking and long wheelbases, which otherwise offer better dynamic performance. Possible long-term solutions for minimizing the effects of off-tracking include rear wheel steering and improved feedback to the driver about the trailer position.

**Track Width**

Allowing 102-inch vehicle width, a new North American standard, is a positive move to increase resistance to rollover, as long as appropriate track width follows.

**Retreaded Tires**

The importation of casings for retreading indicates there is a higher-than-natural proportion of retreaded tires on trucks in Canada at present. Federal standards such as those in the United States are under consideration. Retreads are a normal part of the tire and trucking industries, and are not considered unsafe in themselves, so the higher proportion of retreads may not be a safety issue.

Motor carrier safety regulations in the United States do not allow retreads on the front axles of buses. If retreads are less than safe on the front axles of buses, then they should not be allowed on the front axles of trucks. A resolution to this effect was supported by tire and trucking industry representatives at a meeting of the Commercial Vehicle Safety Alliance Vehicle Committee, but it was later withdrawn because of lack of evidence.

## 8.2 LOADING STANDARDS

Load shifting is not indicated as a significant cause of accidents, although most people have seen lost or displaced truck loads, with obvious possible consequences. Rollover, which may be influenced by shifting or poorly distributed loads, is involved in 6% of all accidents and 18% of fatal accidents involving heavy trucks. (These figures are estimated from a variety of Canadian and United States sources.)

The National Safety Code addresses load security, which is of primary importance. It could contain guidelines for centre of gravity position and integrity (e.g. for liquids), which is vital for resistance to rollover and dynamic stability, especially in certain braking situations. The research necessary to prepare and implement effective standards should be a national and international effort.

## 8.3 IMPROVED DESIGN FOR DYNAMIC PERFORMANCE

A truck can meet the usual design requirements without exceptional ride or road-holding performance, leaving accident avoidance as a performance factor by itself. For accident avoidance, the main consideration is to enhance such things as resistance to rollover. There are few easy solutions. Improvements are possible in control, tire grip, suspensions and fifth wheels. Some regulation may be necessary to encourage use of the best technology in the future.

Following are dynamics-related issues for which no specific action is proposed by Transport Canada, subject to the development of international standards.

**Resistance to Rollover**

Rollover resistance is a complex subject involving terminal buildings (i.e. loading platform heights), track width, tire size and characteristics, suspension, fifth-wheel design, ride considerations, loading practices and feedback to the driver concerning remote trailer behaviour. Allowing wider vehicles is a positive move, and it may be possible to influence loading practices through the National Safety Code. Major design and infrastructure changes are likely to result from evolution encouraged by effective development of international standards.

### Power Steering

Other than for turn rate defects, steering is not named as an accident factor. Truck steering systems could, however, benefit from the kinds of improvements made in passenger cars. The most important of these is power steering, which improves control of heavy vehicles, but which may be omitted for economy reasons. There appear to be no sound measures for governments to take at present.

### Tire Design

Tires play a major role in vehicle dynamic performance. Compromises necessary in their design, for a given level of technology, have a major effect. Regulations could ensure that adhesion is given as much consideration as, for example, price or wear. Appropriate standards do not exist at present to regulate adhesion.

## 8.4 AGGRESSIVENESS

Data from the United States indicates that 71% of fatalities in heavy truck accidents are occupants of other vehicles, mostly passenger cars, and 10% are pedestrians or cyclists (23). Combination trucks have a 446 per 100 million km rate of accidents, less than half that of passenger cars (980), but combination trucks have a rate of fatal accidents nearly twice as great as passenger cars (8.8 vs. 4.5 per 100 million km) (25). Both statistics confirm the obvious, that in a collision with a heavy truck, the other party will receive the most injury. A casual look at a truck suggests several aggressive aspects, most notably that the bumpers are incompatible with those regulated for passenger cars.

### Underride Protection

In fatal multi-vehicle collisions involving a heavy truck, 68% are with the front of the truck. The rest are almost equally divided between the side and rear (25). Rear underride has long been a specific concern, and is the subject of United States and ECE regulations. Side protection is already a feature in some European countries. Attention is now focused on the front of the vehicle as the major opportunity for safety results.

The first need is for lower bumpers matching those regulated for passenger cars. This would involve a structure below the normal chassis level. Collisions are at potentially high speeds, so the structure needs to be strong. Anti-climbing design features, to avoid riding up over an automobile, would also be desirable. A strong bumper at the correct height does not address the difference in mass between trucks and other vehicles, unless controlled energy absorption is also considered.

The resulting structures can be heavy, expensive due to parts that can deform on impact, and have limited ground clearance considering truck wheelbases and overhangs. They could also impede access to brakes and axles. Research and development of practical non-aggressive truck designs is required. Thorough testing is also needed, because half-hearted solutions may not have the desired effectiveness.

### Rear Underride

Rear underride has been a specific concern for many years. Although the rear accounts for less than 20% of fatalities, there is a good argument that a single 2500 mm wide protection would address a high proportion of them. The existing U.S. Motor Carrier Safety Regulation 393.86, not reproduced in Canada, and ECE Regulation No. 58 are not considered complete solutions, but alternatives are controversial.

The U.S. regulation requires a rear bumper or device not more than 762 mm from the ground, 610 mm forward of the extreme rear and 460 mm from the extreme width. It must be "substantially constructed and firmly attached." The ECE regulation specifies not more than 550 mm from the ground, "as close to the rear as possible" and no "more than 100 mm shorter on each side." It also specifies a section height of 100 mm and a strength test up to 100 kN (22 500 lb.) horizontal force at no more than 600 mm from the ground.

The ECE regulation is clearly more stringent, but it may not specify a strong enough guard for cost-benefit advantage in North America, where there are larger vehicles and higher average speeds. Neither addresses energy absorption, essential for improved protection in higher-speed collisions.

Appropriate design criteria such as strength, energy absorption and design target impact speeds are not yet established. Further research is necessary, followed by development of practical improvements. Meanwhile, Canada could determine the value of adopting the U.S. standard. It is unlikely that the more stringent ECE standard would be currently practical for manufacturers or operators.

### Side Protection

Side guards are required in some European countries to address the relatively high number of pedestrian and cyclist accidents. The guards do not need to be very strong to protect pedestrians and cyclists. Additional strength is required for motorcycles. North America has a lower proportion of pedestrian and cyclist accidents, with a consequently different cost-benefit evaluation of side guards.

The U.K. Construction and Use regulations (Statutory Instruments 1982 No. 1576, amendment No. 7) address semitrailers and long wheelbase trucks. A 100 mm section structure with 550 mm maximum height from the ground and 350 mm maximum height of any gap, beginning 3 m from the fifth wheel and extending to within 300 mm of the first rear tire, is subject to a strength test up to 2 kN (450 lb.).

### Front End Designs

The front of a truck is three times more involved in fatal accidents than either the rear or the side, but simple solutions, such as lower bumpers of conventional structure, are expected to address only a small proportion of these accidents. Since better-than-current protection for any part of the truck is expensive, the most benefit may potentially result from tackling the front end design of the truck first.

### Protected Gas Tanks

Fire is involved in 16% of heavy truck occupant fatalities (24). Fire was probably the major cause of death in half of these accidents (page 36). Whereas there seem to be many different origins of fires, in a high proportion of cases it is the truck's own fuel that spills and burns. In view of the small numbers and the variety of circumstances involved, almost all of which have very serious effects, individual effective solutions are not evident. Further research into truck fires should be conducted to determine the ignition and fuelling mechanisms.

Presently, CMVSS 302 requires interior materials that will burn no faster than a specified rate, to allow time to escape. Improvements resulting from changes to this standard are not obvious.

A fuel system protection performance standard, involving a simulated car impact, exists for school buses (CMVSS 301). This performance approach could be an alternative to meeting design requirements for trucks using Liquid Petroleum Gas (CMVSS 301.1) or Compressed Natural Gas (CMVSS 301.2). The moving barrier impact standard could be applied as well to heavy diesel or gasoline trucks.

Other suggested approaches include anti-ignition measures such as "kill switches" for whole electrical systems, careful placement of batteries and methods to prevent fuel leakage or proximity of fuel leakage to heat sources.

Improvements in stages are likely to come from co-ordinated national and international efforts.

### Projections and Sharp Edges

Heavy trucks typically have a number of projections and sharp edges. CMVSS 111 addresses exterior rearview mirrors. The variety of potential problems and lack of data for analysis make it difficult to recommend specific actions. Manufacturers and operators must consider this problem area by giving thorough and consistent attention to manufacturing details.

## 8.5 CRASHWORTHINESS

One hundred and fifty truck drivers are killed annually, on average, according to Transport Canada's count of road fatalities, compared with 425 other people involved in accidents with heavy trucks. A United States study suggests, however, that a truck driver's risk of work-related injury or death is high compared with other occupations. There are 58 deaths annually per 100 000 truck drivers, compared with 60 for mining and quarrying. These are the two most hazardous industries. The average for all industries is 11 (23). Improved crashworthiness is a major part of proposed action to reduce this risk.

### Seat Belts

Seat belts are the most important protection against ejection, a factor in 38% of fatalities among combination truck drivers, and against impact with the interior, a major factor in the remaining 62% (24). Existing two-point seat belts can be expected to address these two factors.

In the 1986 Transport Canada survey of heavy truck operators, 64% of drivers reported that they never wear a seat belt, and another 13% said they wear one some of the time. Of the drivers the interviewer was able to observe, 85% were not wearing a seat belt.

Three-point belts are more effective according to tests. Passive restraints may come into use in the future. Three-point seat belts, which require special engineering for truck applications, are being introduced on North American heavy trucks. It is attractive, but may not yet be justified, to require them for all except centre seating positions.

CMVSS 210 may discourage provision of three-point seat belts because strength requirements are difficult to meet with anchorages on a spring pedestal seat, which is the most attractive arrangement for a truck. The current standard, resistance to 20 g acceleration, is designed for passenger cars.

There has been a suggestion that heavy truck crashworthiness should be aimed at 9 g acceleration, reflecting the lower forces experienced due to dominant weight, and above which crash protection may be impractical because of load integrity limitations. Seat belt anchorages could be optimized accordingly.

It may be advisable to undertake further research to determine optimum design standards for the specific conditions encountered by heavy vehicle drivers.

### Reinforced Cabs

Nineteen percent of fatally injured drivers of combination vehicles had to be extricated from their vehicles (24), suggesting that cab integrity should be investigated. Several standards that address cab strength and rollover protection are in existence.

ECE Regulation No. 29 and a Swedish regulation specify front, rear and roof strength tests using different test methods. ECE procedures include a properly placed dummy to measure survival space, and the ECE regulation requires that the doors remain closed when the cab is loaded with a specified static force. The Swedish test is generally more severe, both in its stated values and by requiring a single cab to be subjected, in sequence, to the three tests. Neither regulation specifies a force or impact value for the side of the cab. Sweden's has been in place since 1961. The ECE regulation has been in effect since 1974. Research is required to relate them to today's North American truck.

Another precedent is CMVSS 216 for passenger cars. This requires the use of a force equivalent to one and a half times the weight of the vehicle, applied at an angle to one side of the roof. SAE also has a number of standards that relate to rollover protection. None are primarily intended for trucks.

### Load Shift Protection

Standards discussed for cab integrity cannot be expected to protect from all kinds of possible load shifting. Standards for load tie-down, and cargo-specific reinforcements to the front structure of the trailer or cargo compartment, would better address this aspect. Despite the obvious potential hazard, intrusion of the rear wall occurs in only 18% of cab intrusion cases. The rest of the intrusion cases are almost equally split between front (30%), sides and roof (26% each) (24).

The United States Motor Carrier Safety Regulations, Part 393.106, specifies height, width, strength and penetration resistance of "front end structures." This section was intentionally omitted from the CCMTA Model Regulation "Security of Loads," adopted in the National Safety Code, because of unclear responsibility — it appears to be an occupational safety issue — and the difficulty of proving compliance. The provision in Part 393.104 of the U.S. regulations requiring protection against longitudinal load movement during deceleration at 6 $m \cdot s^{-2}$ was adopted by the CCMTA.

### Load Security

Load security is an obvious concern and is addressed in the CCMTA Model Regulation "Security of Loads," which will be more widely endorsed as part of the National Safety Code.

### Improvement of Existing Standards

Crashworthiness standards for heavy trucks which were not discussed above include those for glazing materials (CMVSS 205), door latches (CMVSS 206) and seat anchorages (CMVSS 207).

### Application of Existing Passenger Car Standards to Trucks

Passenger car crashworthiness standards offer safety possibilities as long as they are properly adapted for heavy trucks. An example adaptation is a realistic impact protection goal of 9 g rather than 20 g acceleration. The following refer to existing CMVSS standards.

CMVSS 201, Occupant Protection — Requirements for head impact areas and energy absorption are specified. Instrument panels are the chief focus. Trucks have a different interior layout, and as a result more injuries occur to the lower body. A new equivalent standard would need to be developed.

CMVSS 202, Head Restraints — These restraints provide protection against rear-impact whiplash injuries but are almost non-existent in heavy trucks. Head restraints are available, are reasonably popular in passenger cars, and would improve driver safety.

CMVSS 203, Impact Protection — Impact against the steering assembly is reported to be an injury factor in 20% of truck driver injury accidents (24). CMVSS 203 is one of two standards addressing the same problem for passenger cars. It specifies a maximum force that can be transmitted to an impacting body block shaped to represent the driver's chest. This approach would not consider the truck's large horizontal steering wheel, which typically contacts an impacting driver below the rib cage. Another test may need to be developed.

CMVSS 204, Steering Wheel — The steering wheel is one of the subjects of 48 km/h barrier impact tests for passenger cars. It is unlikely that such full-scale testing could be applied to heavy trucks. Because of the layout of truck cabs and their steering systems, the rearward displacement of the steering wheel is not the same problem as it can be in a car.

CMVSS 212, Windshield Mounting — A 48 km/h barrier test for windshield retention would address the most common ejection route, because 40% of ejections are through the windshield (24). This test, however, is suitable only for light vehicles. Retention tested by other means, such as a static force, could be appropriate if windshield size and clear vision is not affected. Use of existing seat belts could reduce the importance of such a standard, particularly because truck windshields are located a greater distance from the driver than they are in cars.

CMVSS 214, Side Door Strength — This standard addresses the resistance of the side structure of a car against an impacting car bumper at regulated height. This is not applicable to truck cabs. Although intrusion of a cab side apparently occurs as frequently as at the front of the roof (24), intrusion distances are small. Side protection could be included as part of an overall cab integrity standard.

### Standards for Sleeper Cabs

There is no Canadian data indicating a safety problem with sleeper berths, which are used in motion relatively little. The Federal Highway Administration (FHWA) has standards including access, communication, ventilation and restraint systems, which could be incorporated into the National Safety Code if a need is identified.

## 8.6 BRAKING

According to the "Heavy Truck Safety Study" (25), inability to stop in time is a factor in 24% of all accidents, brake-induced dynamic instability is a factor in as many as 10%, and identified brake defects are factors in up to 5% of all accidents. The National Highway Traffic Safety Administration (NHTSA) estimates that braking performance may be a contributing factor in one-third of all heavy truck accidents.

Braking is a complex system, and existing accident data does not allow the benefits of individual solutions to be accurately estimated. It is possible, however, to conclude that any real improvement in braking performance will address a contributing factor in a large number of accidents.

### Front-Wheel Brakes

Front-wheel brakes used to be omitted from tractors of combinations because braked steering axles can cause problems such as axle wind-up and loss of steering if the wheels lock. The majority of braking is, in any case, on the two or more laden rear axles.

The problems are overcome with better suspension and brake technology. About 5 to 15% more braking power is available in all conditions with current design front brakes in place. A CMVSS regulation will soon require brakes on all axles of new tractors, and the National Safety Code will, according to agreement at the CCMTA meeting in August, 1987, stipulate that installed brakes be functional. This will parallel motor carrier safety regulations in the United States which went into effect recently. These require brakes to be functional on all axles. It also reflects practice in other countries.

### Updated Braking Regulations

The truck manufacturing and fleet operating industries are such that detailed specifications vary from vehicle to vehicle. Local regulations affect local vehicles. Canadian standards must be kept up to date so that the best technology is included on all vehicles. Front-wheel brakes and manually controlled brake limiting valves (see "Automatic Pressure Limiting Valves" section later in this report) are specific examples of technology included in vehicles made specially for Canada. Local differences should be avoided, except for good reasons.

Braking-related regulations such as CMVSS 105 (hydraulic brakes), CMVSS 106 (brake hoses), CMVSS 116 (brake fluids) and CMVSS 121 (air brakes) should be reviewed for equivalency with United States FMVSS wherever possible. CMVSS and FMVSS 121, concerning air brakes, differed from their inception because Canada correctly avoided ABS, which was not sufficiently developed at that time. The U.S. withdrew parts of its standard, but differences remain between the two versions of the 121 standard. Other braking standards are substantially equivalent.

### Improved Brake Performance

Tests and engineering analysis show that there are opportunities for improving truck braking performance to the level of other traffic. This upgrading requires special attention to the specific factors identified in Table 25.

TABLE 25

OPPORTUNITIES FOR IMPROVING TRUCK BRAKING PERFORMANCE

1. Minimum application time.
2. Balanced force application regardless of load.
3. Maximum braking capability.
4. Suspensions for high brake torque.
5. Controlled use of tire-to-road adhesion on all surfaces.
6. Improved tire-to-road adhesion.
7. Lifetime performance and maintainability.
8. Feedback to driver on malfunctions and maintenance needs.
9. Standards and identification for replacement parts.
10. Braking ability with component failure.
11. Load security commensurate with stopping capability.

Each presents an engineering challenge involving complete systems, for which current technology in the complex trucking industry often does not provide adequate solutions. Industry will develop technology to most efficiently meet reasonable international regulations. Governments should promote development of standards by industry, and regulate minimum acceptable standards where necessary.

Transport Canada is currently involved with the ECE-GRRF (Economic Commission for Europe group of rapporteurs on braking), the SAE braking committee and the Truck Trailer Brake Research Group (sponsored by the American Trucking Association and the Motor Vehicle Manufacturers Association). Continuing participation is important to promote development and ensure that international standards meet Canadian needs.

### Anti-skid Brake Systems (ABS)

Systems that prevent wheel lock can overcome dynamic instability caused by braking, possibly a factor in 10% of accidents, and can provide the means for maximum performance regardless of load, tire condition or road surface. Whereas an automobile with ABS does not necessarily stop in a shorter distance than one without, ABS is a vital ingredient for more powerful truck braking. ABS allows standard axles, tested on dynamometers, to provide maximum braking performance in a variety of vehicle installations, and with a tolerance for degradation.

These attractions led to a 1975 United States air brake standard, FMVSS 121, with axle dynamometer and vehicle stopping performance tests that effectively demanded ABS. Problems from insufficiently developed technology set back ABS application and parts of the standard were withdrawn by court order. There are bills before the United States Congress that would again require ABS. Some fear this might precipitate another false start. Systems are being marketed in Europe and are again available in North America. With modern ABS systems, traction control (ASR) can also be added as an option to provide optimum and safer propulsion control during drive-off on hills and on slippery and icy pavement, and when accelerating on curves. It also reduces wear on tires and drive mechanics. When ABS/ASR is proven for wide application in the carrier industry, regulations may be needed to ensure its widespread application for improved brake performance, availability and use.

### Automatic Slack Adjusters

Air brake lining wear is mechanically adjusted at each wheel. The normal adjustment range affects braking power by up to 30%, and maladjustment can allow the air applicator to "bottom" so that the brakes are inoperative. Well-maintained manual systems provide good results but require frequent and competent attention.

Satisfactory automatic adjustment is highly marketable, just as it was for passenger cars. Technology is likely to provide a solution so that automatic slack adjustment is normal practice.

### Automatic Pressure-Limiting Valves

Pressure-limiting valves modulate brake force distribution by measuring one or more factors, accordingly reducing the pressure to an individual axle or set of axles and thereby changing the braking ratio between axles. The most common type in North America measures application pressure and reduces air to the front wheels until a certain pressure is reached, after which there is no restriction. This is to prevent front wheel lock-up on slippery surfaces when less relative braking is required on the front wheels.

The valves can be installed on trucks with front brakes that are already underpowered. Even with "overpowered" front brakes, the simple logic of the valves reduces an already poor brake effectiveness in the unladen condition, which requires relatively strong front brakes on all surfaces. Use of these kinds of valves could be an improvement for combination vehicles if fifth-wheel load were measured as well as brake application, and both factors used to modulate front brake pressure.

The manually applied front brake limiting valve, allowed and installed in Canada, has the same function but is most likely to be left in the "slippery" (reduced power) mode all the time, seriously reducing braking effectiveness on good surfaces and in the unladen condition. Valves used in Europe to meet adhesion use regulations measure spring deflection as a substitute for load, and modulate brake pressure distribution accordingly. They require careful adjustment to remain effective and are therefore not attractive for regulated general use.

Reliable load sensors and pressure adjusters will continue to be developed for optimum tire and brake life and performance. They will probably appear eventually, but not before anti-skid braking systems solve the most serious problems of emergency braking.

### Compatibility of Replacement Parts

Replacement part compatibility is a major issue for fleet managers, and a factor in maintenance problems and safety performance. Imposed standards could unfavourably restrict design, so the best hope is that industry will develop standards for critical components.

Friction materials are a particular case. Braking performance depends on a pair of friction surfaces, drum to lining or disk to pad. Friction characteristics vary greatly on the production line, let alone between suppliers and over service life, defying efforts to efficiently balance braking performance. Although there is strong industry motivation to develop a standard, the complexity of both the problem and the industry probably requires government involvement. Transport Canada could support international efforts towards standards that can be adopted for new vehicle regulation as well as for replacement parts.

### Retarders

Retarders, which are engine braking enhancing devices, are in common use and are sometimes described as safety features.

### Parking Brakes

There is no evidence of a need to change the parking brake standard, other than perhaps clarifying existing requirements.

## 8.7 DRIVER AWARENESS

Heavy vehicles have dynamic characteristics (oversteer, rollover, etc.) that are not easy to test and that are often beyond the practical experience of even senior professional drivers. In anticipation of an accident situation, the limitations of heavy vehicles need to be constantly stressed to drivers and other road users.

Many problems, such as off-tracking, are inherent because of vehicle size and weight. Others, such as braking instability, require improvements in technology before complete vehicle solutions are available.

There are inherent limitations in the braking performance of heavy trucks, such as long stopping distances and reduced stability when unladen, particularly when "bobtailing." Drivers, operators and other road users should be made and kept well aware of these characteristics. Careful driver selection, training and awareness programs are needed. Off-tracking, handling characteristics, loading and the need for maintenance are among the things that should be stressed in these efforts.

Even loading can have a major influence on handling characteristics, but enforcement of load distribution regulations would be extremely difficult.

Operator care in maintenance and loading, together with driver compensation for braking performance, addresses all braking factors and therefore offers significant potential as a safety measure. Driver and shipper awareness of the criteria for good performance is important. There may be a federal role in preparing and encouraging the distribution of high-quality public information and course material.

## 8.8 ERGONOMICS

Some 40% of accidents involving large trucks have inattention on the part of the truck driver as a contributing factor, and 30% involve negligence (16). Fatigue is involved in a surprisingly low 1% of accidents (23), possibly because existing hours of work laws inhibit allegations of fatigue. Fatigue, inattention and negligence may be influenced by vehicle and environmental factors for which corrective action can be taken. Examples of these factors are control convenience, clear vision, ride, noise and ventilation. These factors also affect overall driver performance, and therefore are a possible factor in many more accidents than direct observation would suggest. Any improvement in the driver's working environment is likely to have a positive safety effect, although this effect would be impossible to quantify.

### Clear Vision Standards

There is no evidence that clear vision is a significant problem that directly causes accidents. Neither is the performance of truck defrosters, windshield washing and wiping systems, mirrors or windows considered unreasonable. A limited but defined accident type involves field of vision, as this factor is implicated in two pedestrian fatalities a year on city streets. Clear vision is fundamental to safe driving, however. Existing standards CMVSS 103, 104, 111 and 205 address this area and should be maintained at the level of international standards.

### Standards for Controls

Convenient and effective controls play a major part in the driver's task and are a marketable item. With so many manufacturers based in many parts of the world, there is a need for standards for identification of controls, in terms of location and action. CMVSS 101 does this for some of the major items, particularly by promoting International Standards Organization (ISO) symbols. Although standardization of controls is desirable, particularly as drivers are often required to change vehicles frequently, there is no evidence of an accident causation factor that would justify further government regulation.

### Noise and Emissions

Noise is a major factor in fatigue and can draw attention away from the driving task. Reduced in-cab noise is marketable, but only at a certain price, and truly quiet cabs are likely to be expensive. Cab noise is an occupational health issue, so standards (CMVSS 1106) are set according to a threshold for hearing damage. Justification for tighter standards may thus be proven for health, but not for safety reasons alone, except possibly as a contribution to an overall improvement in the driving environment.

Exterior noise is a public health issue. Present standards (CMVSS 1106) require measures against engine noise under acceleration but do not address noise associated with engine braking (such as with Jacobs exhaust brakes) or tire noise at highway speeds. Similarly, emissions, both exhaust and evaporative, are public health issues. At present levels, emissions are unlikely to affect driver performance or directly affect the safety of other road users. Public health justification is required to upgrade and enforce noise and emission standards.

### Seats and Ride Comfort

There are no regulations for seats and ride comfort, and there is no evidence to justify setting them. Seat performance and ride comfort, however, are likely to affect driver fatigue, attention and even behaviour. Therefore these factors are, at most, secondary accident factors. Seat design for trucks is relatively sophisticated, with spring suspensions to compensate for the truck ride. Such seats are marketable and widespread. Ride is part of a compromise between load carrying, cost, technology, and weight and dimension regulations. Cost and technology, including sophisticated suspension systems, are likely to be major factors in improving ride. No regulatory action is expected.

### Cab Entry and Exit

Provision of safe cab entry and exit is an occupational safety and health consideration. It is addressed in the United States Motor Carrier Safety Regulations Part 399, which prescribes step, handhold and deck requirements to enhance the safety of motor carrier employees. This standard is available if a problem is identified with Canadian vehicles. No action is proposed. The Motor Carrier Safety Regulations also address sleeper cabs (see section on "Crashworthiness").

### Multi-Piece Rims

These are an occupational safety issue for tire mechanics. Multi-piece rims were for many years the only practical means of securing heavy vehicle tires. They have travelled many safe kilometres, but they have the potential for incorrect assembly and can cause dramatic injury and death, mostly in the workshop. They are being phased out.

## 8.9 CONSPICUITY

Seventy percent of accidents involve more than one vehicle, indicating the importance of factors relating to seeing and judging the size and motion of another vehicle. Twenty-seven percent of accidents and an even higher percentage of fatal accidents occur in darkness, and another 27% of all accidents occur in poor weather or poor light (16). While these figures are not exceptional considering the expected amount of travel in a variety of conditions, they suggest that conspicuity in all conditions may play a significant part in accident prevention.

### Daytime Running Lamps

Daytime running lamps offer significant safety benefits and are the subject of a CMVSS regulation requiring automatic systems in new vehicles. Complementary action should be taken to ensure that trucks that do not at present have daytime running lights are also conspicuous, by use of headlamps or retrofit systems. Daytime running light systems that do not activate all lamps require monitoring and possible action, so that all vehicles have position lamps on in poor lighting conditions. Complementary provincial regulations and awareness programs are needed.

### Reflective Surfaces and Reflective Triangles

It is a reasonable hypothesis that the more visible and identifiable a vehicle is, the better. Cost and possible overuse, however, require care in application of lights and reflectors.

The University of Michigan reports an overinvolvement of flatbeds in rear-end collisions in all situations except on undivided highways during the day ("Rear-end Collisions and Conspicuity"). This supports observations that a flatbed is less conspicuous and easier to misjudge than other truck combinations, and suggests action to make them more prominent. More importantly, if the difference is due to prominence, then prominence should also be a significant factor in the absolute numbers of accidents involving other kinds of heavy vehicles and other kinds of collisions.

An NHTSA notice (1987-09-18) cites accident reduction experience in fleet studies involving vehicles treated with retroreflective material.

Specific solutions include reflective triangles on the rear of heavy vehicles (Europe), reflective mudflaps (Australia) and use of reflective tape to show the outline of the vehicle. Since any or all of these are feasible, there is an argument for their promotion and for appropriate studies to see if their application by regulation is justified.

### Improved Original Equipment Lighting

The present CMVSS 108 is comprehensive and generally considered satisfactory. It is the subject of constant review at national and international levels, leading to regular amendments. This is an effective process needing no specific action.

Weaknesses remain, particularly in rear lighting of trucks. Manufacturers find it difficult to place tail lamps and clearance lamps at the extreme width, and identification lamps at the extreme height, lessening their effectiveness in identifying the vehicle and its size. Dirt obscures lamps and can seriously reduce their effectiveness. Improved technology should allow lamps to be positioned optimally to indicate vehicle extremes and to avoid the collection of road dirt. The use of shockproof and impact-proof lamps, and manufacturing techniques permitting structural members with slots for inset lamps, are potentially attractive improvements.

In the case of flatbed trucks and trailers and other vehicles such as dump trucks, enforcement of the existing standard could be reviewed to ensure that all manufacturers are using the best techniques to comply. A continuously updated manual that catalogues design problems and deviations from the full intent of the standard, such as low separation of tail lamps, may help enforcement. The slow-to-respond regulation-making process would not be as effective a means of enforcement in this area. It may become possible to upgrade the standard to require, for example, a minimum vertical separation of tail and clearance lamps, to provide some depth to the display. Continuing enforcement pressure at federal and provincial levels, together with awareness programs, will improve compliance with the intent of CMVSS 108.

### Replacement Lamp Standards

Replacement lamps are not subject to CMVSS 108 and there is no assurance that they meet the performance requirements, although most suppliers do manufacture to current North American standards. It may be better to regulate the supply of lamps rather than only one of the groups of lamp users, the truck manufacturers.

### Lamp Monitoring

Lamp failure remains a frequent occurrence on the road. A driver is aware of a problem only when making a walk-around check. A clear in-cab lamp monitoring system may help to minimize the exposure of a truck with incomplete lighting, particularly if all lamps are activated during the day so that checking is continuous. Development of satisfactory systems is likely to take place on an international basis.

### Splash and Spray Prevention Devices

Although a direct involvement in accidents has not been established, splash and spray caused by the wheels of heavy trucks makes the task of other drivers more difficult. It often makes otherwise reasonable passing hazardous for lower vehicles. Unsurprisingly, there is pressure from motorist groups for countermeasures.

Provincial regulations require mudflaps, usually rectangular hard rubber flaps hanging vertically behind the rearmost wheels. There are several possible improvements. Many European and some North American trucks have short mudguards around the circumference of the wheel. These can be enhanced with deeper skirts, possibly in a flexible material (as on buses) to avoid damaging a tire on contact, and more circumferential cover with a flexible flap close to the ground. Textured "interior" surfaces are called spray suppressants. They are textured either by profile (e.g. corrugated) or special material (e.g. bristles) to collect, break up and direct spray. They can be applied to either vertical mudflaps or circumferential mudguards.

These approaches involve whole vehicle aerodynamics and include air dams, which are flexible gap fillers between tractors and trailers, together with angled mudflaps in front of and behind wheels. Tests demonstrate certain advantages of these various measures, although none controls splash and spray adequately to significantly reduce the visibility problem. The best ones are expensive, and some have problems of practicality.

Tests in Canada (18) show that existing types of mudflaps with a textured "interior" surface experience greater snow and ice build up, demanding stronger than normal supports for satisfactory operation. These kinds of devices may, however, be straightforward enough to find acceptance in the market without regulation, possibly with some help from awareness programs. More elaborate devices can be heavy, bulky and susceptible to damage.

It is difficult to establish positive cost-benefit information based on safety, and a performance standard for splash and spray prevention remains to be devised. Weather and road conditions are difficult to duplicate, and tests that are too simple lack relevance to the real world. This is causing a major delay in United States regulatory action in response to the Surface Transportation Assistance Act of 1982. The alternative, more likely to succeed in the short term, is the development of a design standard based on consensus. This is the subject of a United States Advanced Notice of Proposed Rulemaking (1987-09-28).

In the long term, research may enable new approaches to vehicle and tire design. Together with improved road surface draining, this would reduce splash and spray at source. Already the UK has a local regulation based on a design standard (BS AU 200, 1984) which includes mudguard dimensions and a test for "spray reducing devices." Oregon requires large rigs (over 36 000 kg) to be equipped against spray from a list of approved devices established on the basis of state-run tests.

Action on splash and spray can only be justified on the basis of its contribution to an improvement in the overall driving environment, with possible safety implications. Participation in international standard-making efforts is most likely to yield a practical solution. When a design or performance standard is established, it will require application for original equipment, replacement parts and maintenance.

## 8.10 IMPROVED MAINTENANCE

The Report of the Ontario Commission on Truck Safety (15) quotes mechanical failure as an accident causation factor in 20% of cases. The Office of Technology Assessment of the United States Congress reports preliminary results of its truck safety study showing vehicle age as a frequent factor and defective brakes as a most serious safety problem.

An NHTSA study (25) reported that 91% of accident cases involving combination unit trucks had no mechanical deficiency contribution. Three percent were caused by braking defects, 2% by tire defects and 1% by lighting defects. The rest were caused by defects in various other items. Given the difficulty of establishing mechanical deficiency — for example, many factors influence the power and stability of brakes — it seems likely that defects are underreported.

Poorly maintained brakes, even without observed defects, can yield significantly less than optimum performance and seriously affect braking stability. Similarly, worn or underinflated tires, slack suspension and steering joints or 5th wheels and poorly distributed loads have a major influence on the behaviour of a vehicle. Programs that improve maintenance directly address the observed mechanical deficiencies and possibly many others that are never recorded. The National Safety Code brings together comprehensive maintenance standards as well as enforcement by roadside inspection and facility audits. Transport Canada encourages and participates in the development and financing of this code.

### Parts Standards

Shortcomings in replacement parts have not been identified as an accident cause or as a factor in observed defects. Stopping ability and other performance areas depend, however, on reliable replacement parts. Stringent standards apply to certain new vehicle components, but there is no aftermarket control. The Motor Vehicle Safety Act does not deal with replacement parts such as brake hoses, and there is no assurance that replacement parts meet the standards for new vehicle components. Provincial regulations and the National Safety Code could refer to federal standards, but provincial governments have not responded positively to this approach. Application of existing standards to replacement parts should be practical and could positively influence maintenance practices and overall performance.

CMVSS 106, concerning brake hoses, and CMVSS 116, concerning hydraulic fluids, apply to braking. Standards for replacement parts would help ensure continuing "original-equipment" performance, such as required by CMVSS 105, concerning hydraulic brakes, and CMVSS 121, concerning air brakes. Standards for components that could apply equally to replacement parts are CMVSS 108, lighting; CMVSS 205, glazing materials; CMVSS 206, door latches; CMVSS 209, seat belt assemblies; and CMVSS 302, flammability.

### Correction of Manufacturers' Defects

Section 8 of the Motor Vehicle Safety Act (MVSA) requires manufacturers to notify vehicle owners of safety-related defects. In fiscal year 1985-86 there were 63 recalls affecting 62 000 vehicles classified as over 4500 kg in weight. In the majority of cases manufacturers become aware of a defect, give the necessary notice and repair the defect at no cost to the owner. Transport Canada investigates alleged defects and monitors recalls and their completion rate (in terms of vehicles fixed).

An ongoing problem is low correction rates, particularly for trucks. For 44 recalls in 1985 there was an average completion rate of 57%, while for passenger cars the rate was 71%. This may not be the problem it seems, because heavy trucks are not often taken to official dealers, and owners do not report repairs. The National Safety Code requires carriers to correct MVSA Section 8 defects, offering an opportunity for code-related audit and awareness programs to address the correction rates.

Transport Canada monitors accidents and public complaints, and investigates alleged defects. Where safety defects are identified, MVSA, Section 8 obliges manufacturers to take action. Transport Canada initiated, for example, 11 brake-related recalls for heavy vehicles during the 10-year period ending in 1985. Except for the constant search for better information systems, no changes are suggested for this program.

### Lifetime Performance Standards

The less maintenance a vehicle requires and the easier it is to service, the less the chance of deficiencies. For most safety-related items the advantages are marketable, and better lifetime performance will be incorporated as technology progresses. Regulated items that may not be marketable, such as enhanced emergency braking, supplementary lights, seat belts and emission systems, may require lifetime performance or maintenance specifications to be sure these less marketable items are maintained, as addressed in some existing standards (CMVSS 105, 108, 209, 1101).

### On-Board Monitoring

Technological progress allows more systems to be monitored for correct performance, both on the road and in the maintenance shop. Electronics offers simple and trouble-free sensors and data processing, so that many parts can be monitored for appropriate feedback to driver and service personnel. There are increasing possibilities for useful feedback, particularly in braking, lighting and tire inflation pressure, where status can change during a single trip and repairs are possible on the road. In some safety-related cases, such as air brake pressure (CMVSS 121), regulation is necessary to ensure that monitors are installed and are functioning. Progress in developing effective and standard monitoring technology for safety systems is likely to be made at the international level.

## 8.11 TRUCK ELECTRONICS

The most dramatic technological improvement in truck productivity will not directly involve the trucks. A communication system will provide location control for a carrier's fleet. Traffic flow, vehicle assignment and routings will be supported and optimized by a centralized system. Each vehicle will be in voice and in-vehicle terminal communication with the dispatcher. Some shippers will have computerized access to vehicle location, and hence expected time of arrival of their shipments. Already the most convenient mode, trucking will become more convenient.

A 1986 study undertaken by TRW Inc. (20) predicted the introduction and expected cost of some 54 truck electronic systems, listed in Table 26. The predictions were based on input from a panel of 36 experts in the fields of vehicle electronics, truck manufacturing and fleet management. The study estimated that the 35 most likely systems (each marked by an asterisk in Table 26) would add about $12 000 to the cost of a truck. The study states that a reduction in truck operating costs of 7.4% is "readily achievable" through the use of these systems. On the basis of this cost savings, the $12 000 investment would be paid back in one year.

## 8.12 POTENTIAL R&D OPPORTUNITIES

### 8.12.1 Vehicle Safety

1. Consider implications of incorporating design features which reduce aggressiveness and expand use of underride protection, controlled front end structure energy absorption, uniform bumper height, protected fuel tanks, etc.
2. Consider implications of incorporating design features which improve crashworthiness and occupant protection through use of seat belts, reinforced cabs, load shift protection, load security, upgraded CMVSS, upgraded sleeper cabs, etc.
3. Consider implications of maximizing braking efficiency and effectiveness through promoting use of ABS, component compatibility, front axle braking, etc.
4. Consider design features which optimize ergonomic and traffic factors such as clear vision, control identification, noise control, ride quality, cab entry and exit, prominence, splash and spray control, etc.

### 8.12.2 Combination Vehicle Dynamics

1. Promote the identification of those weight and dimension design criteria which will enable straight trucks, trucks and full trailers, and tandem-steered power units to meet the RTAC/CCMTA stability, control and off-tracking performance standards for heavy commercial vehicles.

## TABLE 26

## TRUCK ELECTRONIC SYSTEMS PREDICTED BY TRW INC. STUDY

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### VEHICLE OPERATION

- * Navigation
  - Precise location
  - Security — antitheft
- * Security — locate stolen vehicle
- * Automatic load advisory
- * Automatic operation advisory
- * Automatic weighing
  - Axle load sensing
  - Cargo monitoring
  - Load dispense control
  - Automatic load broadcast
- * Communication system

### VEHICLE CONTROLS

- * Wheel lock control
- * Tire pressure monitoring
- * Road condition monitoring
  - Headway monitoring
  - Headway control
- * Automatic brake control
  - Electronically controlled steering
  - Automatic road-following steering
- * Steer by wire
- * Aerodynamic surface control
  - Vehicle speed control
- * Adaptive suspension
- * Coordinated tractor-trailer steering

### DRIVETRAIN CONTROLS

- Engine speed control
- Full engine control
- Transmission control
- Axle control
- * Integrated drive train control
  - PTO control
- * Engine protection
- * Remote engine control

### INFORMATION AND DISPLAYS

- * Full digital displays
- * Vehicle life history recorders
- * Crash recorders
- * Service advisory and record
- * Trip data record
- * CRT screen with map

### ELECTRICAL SYSTEM

- * 24v to 48v system
- * Serial data link
- * Multiplexing

### COMFORT AND CONVENIENCE

- * Cab environment control
- * Lighting control
- * Seat control
- * Rear obstacle detection
  - 5th wheel hookup
- * Mirror control
- * Blind spot detector

### DRIVER PERFORMANCE MONITORS

- * Physiological evaluation
  - Chemically impaired driver
- * Fatigued driver
- * Erratic driver
- * Skill evaluation

NOTE

* indicates systems most likely to be introduced

2. Assist in the development of stability and control performance criteria for trailer and semitrailer coupling devices.
3. Examine semi-active and active trailer axle steering mechanisms which reduce vehicle safest path and friction demand while retaining desirable transient off-tracking behaviour.
4. Examine the dynamics of jackknifing and develop anti-jackknife devices for tractor-trailers that are actuated independently of the driver.
5. Enhance engineering tools for analysis of combination vehicle dynamics, including the development of expert system software to facilitate and simplify the analysis task, and extending existing software to treat straight trucks, trucks and trailers, jeeps and boosters.
6. Develop better understanding of the fundamentals of liquid tanker slosh dynamics, and improve tank design for reduced slosh.

### 8.12.3 Suspension Dynamics

1. Promote an internationally acceptable test methodology and nomenclature for describing the parametric values of single and multiple axle suspension systems.
2. Determine the influence of the parameters of mixed suspensions, in a Canadian context, on vehicle control and stability.
3. Promote the development and use of high-stability suspension systems.

### 8.12.4 Interface Between Roadway and Suspension

Whereas the RTAC weights and dimensions study considered the impact individual axles and axle groups have on pavements and structures, the overall effect of the combination vehicle should be considered.

### 8.12.5 Energy and Environmental Conservation and Fuels Substitution

1. Undertake more fundamental research for the development of new technologies and improvements to existing technologies for engine and drive tribology, energy efficiency, use of alternative fuels and assessment of fuels and fuel additives.
2. Minimize aerodynamic drag, rolling resistance and lateral scuffing.
3. Minimize undesirable exhaust emissions.

### 8.12.6 On-Board Electronics

Incorporate and/or demonstrate as many electronic features as practical, with emphasis on those likely to be introduced within the next five years.

### 8.12.7 Advanced Integrated Vehicle Technology Feasibility Study

Due to the large number of safety and productivity issues that need to be addressed, including those related to transportation of energy and dangerous goods, it may be advantageous to investigate the feasibility of an advanced concept vehicle that incorporates, to the greatest extent possible, the latest technology in each design area. In addition to investigating the feasibility of the technologies, a properly managed program might also promote transport technology inflow to numerous Canadian companies, unify the Canadian truck transport research community within a single project, assist Canadian vehicle design and manufacturing firms in becoming familiar with the latest technology (thereby promoting them in international markets), and demonstrate to the transport industry the possible application of new electronic equipment. The project could incorporate appropriate technologies addressing the main R&D opportunity areas identified herein.

### 8.12.8 Productivity of Special Purpose Vehicles

1. In view of expected increased competition between transportation modes and between nations, research and development is needed to enhance the productivity of highway freight vehicles. This R&D should particularly focus on the design and operation of special-purpose vehicles such as auto carriers, furniture vans and household goods movers, logging industry vehicles, extended vehicle combinations and cargo containers that can be used by more than one transportation mode.
2. Improve heavy vehicle operation on non-paved and thinly-paved surfaces (e.g. improved tractor-truck drawbar pull capacity for logging vehicles).

## 9. INFRASTRUCTURE TECHNOLOGY RESEARCH

Current federal expenditures for road infrastructure amount to $225 million per year. These expenditures include new construction, rehabilitation, maintenance, operation of pavements and bridges which are the exclusive responsibility of the federal government, and development of highways under cooperative funding agreements with the provinces. Under agreements already in place, the federal government will spend $1.233 billion over the next fifteen years in contributions to the provinces for road construction. It is generally believed that many of the ongoing maintenance costs can be significantly reduced by the development of specific technologies.

The federal government is fully responsible for international bridges, bridges linking provincial jurisdictions, roadways within National Parks, the Alaska Highway through British Columbia, roadways and bridges within the National Capital Commission areas and the Yukon and North West Territories, and a number of structures constructed under provincial and regional agreements. The federal government has joint responsibility for the maintenance and operation of certain highways due to cooperative agreements such as the ERDA programs and the Yellowhead Highway Reconstruction Program. Over the next decade, the federal government will likely be extensively involved in the reconstruction of the Trans-Canada Highway through Eastern Canada, particularly in Newfoundland.

The federal government is one of the largest sources of highway funds in Canada, exceeding the annual highway budgets of six of the ten provinces. It would therefore be prudent for Transport Canada to establish both safety and maintenance criteria within its procurement and contribution objectives, in order to minimize its long-term contributions, and to ensure that technical innovations in highway construction and maintenance techniques are adopted.

The SHRP and C-SHRP programs, to which Transport Canada currently contributes, focus on the rehabilitation and maintenance of existing highways. The programs, however, do not address the relationship between design standards and road safety, nor do they focus on the interactions between vehicle vertical dynamics and pavement and bridge damage. With the current trend towards larger and heavier commercial vehicles, and smaller and lighter passenger vehicles, the geometric, signage and barrier standards developed in the 1950s and 1960s may no longer be adequate. The RTAC weights and dimensions study has shown that the low-speed off-tracking characteristics used in the development of the existing geometric templates and design standards may be inappropriate for expressway curves, and that significant differences exist in the vertical response of different suspension systems. Work conducted by UMTRI has already shown many existing interstate interchange curves in the United States are inadequate and pose safety hazards.

### Suspension Vertical and Lateral Dynamics

Work conducted by the National Research Council towards the RTAC weights and dimensions study demonstrated the range of vertical forces exerted on pavements due to the vertical displacement permitted by different suspension systems. A hypothesis has been promoted that, by understanding the fundamental characteristics of various heavy truck single and multiple axle suspensions, these vertical forces can be lowered. It is argued that lower vertical dynamic forces will extend pavement life. Similarly, load equalization between axles in multiple axle suspensions, and control of lateral roll and side scuff in multiple axle suspensions, will reduce pavement stress and extend pavement life.

**Construction, Maintenance and Reconstruction**

The prevalent paving material used in Canada is asphalt, which, in simple terms, is the residue left over after all other usable petroleum products have been taken out of crude oil. As the refinery process becomes more efficient, however, the quantity and quality of the asphaltic residue is being depleted. Already recycling programs are making better use of existing resources, but the search for alternatives to asphaltic mix must be well established before the next energy shortage. Two oil companies have already begun this research and have developed a polymer mix which is said to have enhanced high and low-temperature qualities, but is very expensive.

Similarly, several jurisdictions do not have an ample supply of aggregate for pavement structures. Identification of alternative materials may assist in reducing pavement construction costs, and extend existing supplies. As existing highways wear, improperly executed maintenance can defeat safety features. For example, urban growth and vegetation can obscure critical sight distances, the reflective qualities of highway signs can fall below minimum acceptable standards, retrofitted signs might obscure or confuse original traffic control devices, and multiple pavement overlays can diminish overhead clearances or lower what was effective guardrail height. Highway reconstruction offers an opportunity to review and to update safety features.

**Accident Location Data**

Researchers have understood the relationship between highway geometrics and vehicle dynamic behaviour for some time. Many highway accident sites go unnoticed by statistical sampling techniques, however, because the accident location is not documented with sufficient accuracy in the police report. Providing roadside highway location markers may help.

**Traffic Barrier, Signpost and Luminar Performance**

Roadside furniture has been designed to mitigate injuries to the occupants of errant vehicles. The design criteria for traffic barriers, signposts and luminars were established for vehicles that were designed before the fuel crisis, however. Today's front-wheel drive unibody passenger vehicles are lighter and exhibit fundamentally different crush characteristics than the older rear-wheel drive, perimeter frame designs. Meanwhile, the increased use of road transport has increased the size and number of heavy commercial vehicles. Thus collision standards for roadside furniture may no longer be appropriate.

**Splash and Spray**

The public has called for a major reduction in the splash and spray of commercial vehicles, and significant work has been done on devices for heavy commercial vehicles that would help accomplish this. The texture of the road surface, however, can also have a major effect not only on splash and spray, but also on vehicle stability, dynamic performance and nighttime surface reflection.

## 9.1 POTENTIAL R&D OPPORTUNITIES

Research into vehicle-to-infrastructure and infrastructure-to-vehicle effects, and roadway design, must be advanced in cooperation with the provinces.

### 9.1.1 Dynamics of Vehicle Loads and Suspensions

In conjunction with the international research community, explore the potential for an integrated suspension and pavement design criteria.

1. Conduct fundamental research into suspension non-linear qualities and load sharing capabilities.
2. Relate suspension parameters to pavement life and vehicle stability.
3. Relate road roughness to suspension ride and handling characteristics.
4. Determine the relationship between pavement design and vehicle ride within a Canadian context.
5. Develop economic impact assessment of pavement-to-ride relationship.

### 9.1.2 Technology to Minimize Vehicle Contribution to Road Wear

1. Develop suspensions for improved load equalization, including intelligent suspensions for adaptability to differing road conditions.
2. Reduce negative effects of belly and airlift axles on pavement rutting.
3. Reduce lateral forces in tridem axle groups.
4. Develop means to evaluate and rate suspension systems and appropriate load carrying capability.
5. Develop axle configurations for improved weight distribution, reduced road wear and enhanced vehicle stability.

### 9.1.3 Alternative Materials for Pavements and Structures

Investigate alternative materials for use in pavements and structures.

1. Energy-efficient asphalt mixes.
2. Asphalt mix alternatives.
3. Aggregate and structural materials substitution in pavements and structures.
4. Alternative materials in structures to combat corrosion and environmental deterioration.
5. Advanced technology solutions to combat corrosion in structures.

### 9.1.4 C-SHRP and SHRP

Continue to provide financial support for the SHRP and C-SHRP projects.

### 9.1.5 Highway Geometrics

Review the existing specifications for highway geometrics, and update them when necessary, to ensure they reflect the dynamic performance of the new generation of Canadian heavy commercial vehicles. Ensure all new construction and rehabilitation projects receiving federal funds conform to the revised standards.

### 9.1.6 National Accident Location System

Establish a national standard for locating accident sites, and require all future projects receiving federal financing to conform to the standard.

### 9.1.7 Roadside Furniture Specifications

Review existing specifications for roadside furniture, and update them when necessary, to ensure compatibility with today's lightweight front-wheel drive passenger vehicles and the new generation of heavy commercial vehicles.

### 9.1.8 Influence of Pavements on Splash and Spray

Review pavement surfacing techniques to determine the extent to which wheel splash and spray can be reduced without detriment to other desirable pavement requirements.

### 9.1.9 Furniture Maintenance Handbook

Publish a highway safety furniture maintenance handbook to be followed on all highways supported through federal funds.

## 10. COMPLIANCE TECHNOLOGY RESEARCH

The provincial and territorial governments operate approximately 150 permanent, 150 portable and 50 weigh-in-motion (WIM) weigh scales, with about 900 staff and a combined annual budget approaching $300 million. The permanent facilities operate for periods ranging from only a few hours each year up to 24 hours per day, 7 days per week.

Weigh scales staff in the majority of jurisdictions do more than just weigh trucks. Many facilities, also referred to as Truck Inspection Stations, monitor vehicle licences and registration, vehicle insurance, motor fuel and sales taxes, motor carrier authority, driver licencing, inspection certificates, mechanical condition, dangerous goods placarding, driver training cards, special operating permits and vehicle dimensions. With the introduction of the National Safety Code, these facilities will also soon be monitoring hours of service.

The weigh scales frequently provide a necessary service to commercial vehicle operations, particularly at border crossing points. All commercial vehicles must be properly registered and licenced in each jurisdiction they operate within. Provincial governments provide various short-term licences, permits and operating authorities at weigh scales for carriers who do not normally enter the province. Because the commercial transport industry operates 24 hours per day, so must the service-oriented weigh scales.

Most violations of provincial regulations result in civil charges against either the vehicle owner, the operator or the driver. Because many of the charges are challenged through the courts, the weighmaster must be prepared to present sufficient evidence of the violation to a court of law. The specifics determining each offence vary from province to province, depending on the wording of statutes, thus making a universal prosecution or defence very difficult. There are a few items which may be addressed nationally, however. A national standard for axle load sensors is needed, independent of the federal Weights and Measures Act. Guidance is also needed for mounting a successful prosecution involving strict liability.

A study conducted by the Province of Saskatchewan in 1985 (21) showed the interrelationship between enforcement levels and the number of violations. The study found that a relatively low level of enforcement could result in relatively high levels of compliance. It also showed that 100% enforcement did not result in 100% compliance.

With the current number of tasks assigned to the inspection stations, it is likely that one or more of their duties takes precedence over the others. For example, in a facility staffed by one person, an operator at the counter seeking a permit cannot be ignored while the weighmaster monitors vehicles passing over the weigh scale deck. Therefore, procedures and equipment should be developed which would permit fully automatic identification of violators, and also provide the weighmaster with sufficient evidence to issue a violation and sufficient information to issue requested documentation or permits.

### 10.1 POTENTIAL R&D OPPORTUNITIES

Technology should be used to improve the accuracy and productivity of techniques that monitor compliance with national regulations.

#### 10.1.1 National Standard for Highway Scales

Establish a national standard for static axle scales, on-board weigh scales and weigh-in-motion scales, independent of the federal Weights and Measures Act.

### 10.1.2 Automatic Vehicle Identification and Provincial Records

Demonstrate a system for integrating automatic vehicle identification and provincial records (registration, licencing, sales and fuel tax, operation authority, inspection certification, insurance, National Safety Code (NSC) information and special operating permits) so as to bring violations to the attention of the weighmaster.

### 10.1.3 On-Board Weigh Scale Technology

Develop on-board weigh scale technology which allows vehicle operators to maximize payload while remaining within legal limits.

### 10.1.4 Weigh-in-Motion Scales

Improve the technology of weigh-in-motion scales to lower costs and to improve accuracy and reliability at higher speeds in order to reduce traffic delays, and expand automation features to reduce staffing costs.

# 11. OPERATIONAL TECHNOLOGY RESEARCH

## 11.1 DRIVER PERFORMANCE TECHNOLOGIES

Traffic safety experts generally agree that approximately 5 to 10% of all vehicle accidents are directly attributable to a mechanical design or defect in the vehicle, and perhaps another 10% may be attributed to the design and/or maintenance of the roadway. All but a very small percentage of the remaining accidents must therefore be attributed to driver error. This fact has been widely recognized in the United States and Canada, where major initiatives are now being undertaken to reduce the number of accidents caused by driver error.

In the United States, the Commercial Motor Vehicle Safety Act of 1986 limits commercial drivers to a single licence, requires driver examination to be conducted in a vehicle appropriate to the class of licence being sought, requires states to forward information on violations to the driver's state of licensure, requires the state of licensure to keep a file of violations and requires the driver to report all violations to his employer. These regulatory initiatives are designed to ensure commercial vehicle drivers are qualified to operate their vehicles. It identifies drivers with poor driving records so they may be kept or removed from the driving task.

In Canada, non-uniform provincial standards governing single licenses, driver qualifications, driver examinations and violation record-keeping have existed for several decades. However, not until the Motor Vehicle Transportation Act of 1988, and more particularly the National Safety Code, has any serious effort been made to develop a nationally uniform standard for commercial drivers, and to impose nationally uniform compliance requirements on industry and on the jurisdictional governments. The National Safety Code specifically addresses commercial vehicle driver license classifications, training and examination; violation records and interjurisdictional records exchange, and drivers' hours of service. Much work remains to be done on specific human factors relating to vehicle safety. There is a clear need to develop the technologies which train or test for the desired capabilities. Technologies to facilitate the interjurisdictional transfer of driver information must be identified and developed.

## 11.2 VEHICLE AND FLEET OPERATIONAL TECHNOLOGIES

Truck dispatch operations either provide detailed route instructions before the start of a trip or during the course of a trip. In the former case computer technology currently exists which calculates the shortest route time and includes factors for specific appointment times, peak traffic volumes and scheduled detours. In the case of instructions en route, however, active vehicle location technology has not yet been sufficiently integrated into commercial transport fleets to allow automated route calculation. En-route instruction currently requires a voice communications link between the driver and the dispatcher in order for the dispatcher to know the location of the vehicle.

Knowing the locations of all the vehicles, the dispatcher can select the next appropriate destination for each vehicle. If a passive link between the vehicle and a dispatch computer could establish the location of each vehicle, an expert system could calculate en-route changes so as to maximize the fleet efficiency. Similarly, passive vehicle location technology can be used to trace en-route cargo, which is becoming more necessary with just-in-time manufacturing techniques.

Passive vehicle location technology can have other applications, particularly with respect to highway planning, dangerous goods routing, emergency response vehicle security, and driver route guidance.

## 11.3 POTENTIAL R&D OPPORTUNITIES

It is vital to investigate advanced technologies for improved operations in the highway transport sector, and related human factors. This will help Canadian transportation industries operate more safely and efficiently, and keep pace with emerging technologies. Potential R&D areas include the following.

### 11.3.1 Driver Behaviour and Limits of Performance

1. Develop a better understanding of driver reactions to external perceptions and stimuli, and establish limits of performance.
2. Study effects of cab environment and ergonomics on driver performance and fatigue, including the effects of introducing additional technologies into the cab such as cellular telephones, video screens and route guidance systems.

### 11.3.2 Ergonomics and Human Factors Engineering

1. Improve ergonomics and human factors engineering to reduce driver fatigue and increase driver awareness of events occurring around the vehicle.

### 11.3.3 Driver Training and Evaluation Technologies

1. Develop driver training technologies that promote uniform minimum qualifications for operators under the National Safety Code.
2. Develop interactive heavy vehicle driver training simulators for use in driver training, licensing and fundamental research into driver behaviour and limits of performance.
3. Develop effective educational material on the handling of heavy vehicle dynamics such as stability, the control aspects of various vehicle configurations and the handling of brake systems on heavy vehicles.

### 11.3.4 Driver Monitoring Systems for Medical and Physical Conditions

1. Develop driver monitoring systems to record hours of service and to provide feedback on the driver's condition, to improve driver decisions.
2. Develop effective warning devices for lack of driver alertness.

### 11.3.5 Driving Aids for Improved Vehicle Control

1. Develop systems that provide the driver with advance warning of potentially hazardous conditions such as a shift in trailer centre of gravity, trailer swing or impending vehicle upset.

### 11.3.6 Dangerous Goods Transportation

1. Develop more efficient and effective technologies for non-destructive testing of materials.
2. Expand applications of expert systems for rapid emergency response, such as presently being examined for dispatching assistance and interpretation of dangerous goods regulations.

3. Develop improved communications systems, such as field communications equipment, for more rapid and secure emergency response.
4. Develop secure electronic technologies for positive identification of product being transported, for effective emergency response under all conditions.
5. Develop technologies for more effective hazard containment, including new and safer containment materials, tank explosion suppression systems and improved safety performance of fittings and release valves.

### 11.3.7 Fleet and Traffic Management

Examine communication and computer technologies in support of fleet management applications such as the following. Detailed items are presented in Table 27.

1. Vehicle and cargo position tracking.
2. Route guidance.
3. Vehicle, cargo and occupant security.
4. Driver effectiveness.
5. Ambulance and fire.

### 11.3.8 Travel Advisory and Optimization of Highway System Use Around Principal Transportation Hubs

Examine communication and computer technologies in support of travel advisory applications such as the following. Detailed items are presented in Table 28.

1. Road map.
2. Traffic rules.
3. Route guidance.
4. Emergency response.
5. Public service messages.
6. Roadside and community services information.

### 11.3.9 Mobile Office

Examine communication and computer technologies in support of mobile office applications such as the following. Detailed items are presented in Table 29.

1. Word processing and computing.
2. Communications.
3. Freight.
4. Home base control.

## TABLE 27

## POTENTIAL APPLICATIONS OF COMMUNICATION AND COMPUTER TECHNOLOGIES IN SUPPORT OF FLEET MANAGEMENT

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1. **VEHICLE AND CARGO POSITION TRACKING**
   - a. Display of vehicle and shipment location at control centre (for postal and courier services, administrative vehicles, tractor-trailers, cargo vans, etc.).
   - b. Dispatching and rerouting for freight, taxi and emergency.
   - c. Schedule, route, safety adherence (central dispatch intervention).
   - d. Load factor monitoring and operation of destination and passenger information panels.
   - e. Emergency vehicles control for police, fire, ambulance and public utilities (to reduce response time and increase officer safety).
2. **ROUTE GUIDANCE**
   - a. Motor carriers' road atlas and intercity routing guides (including tolls).
   - b. Industrial site access maps (comes with advance block signals).
   - c. Maximum dimensions and weights for roads, bridges and tunnels.
   - d. Municipal regulations concerning truck routes and operating days and hours.
   - e. Heavy specialized carriers' routes and hazardous cargo routes.
   - f. Road geometrics alerts such as recommended maximum ramp speeds, etc.
   - g. Weather alerts for wind, icing of road surface, snow squalls, etc.
   - h. Pre-departure and pre-entry advisory for anticipated clearance time.
3. **VEHICLE, CARGO AND OCCUPANT SECURITY**
   - a. Automated emergency response system to vehicle problems (such as for theft of parked vehicles).
   - b. Distress calls (unruly passengers, heist), help request for disabled vehicles, etc.
   - c. Convoy management for commercial and private vehicles.
   - d. Electronic guard dog.
4. **DRIVER EFFECTIVENESS**
   - a. Video and audio instructions.
   - b. Feedback:
     - — driving performance related to fuel efficiency, headway and handling; and
     - — rules of the road (from map data base and signs).
5. **AMBULANCE AND FIRE**
   - a. Dangerous chemicals referral system by class and identifiers.
   - b. Emergency information on building layout and content (transmission of floor plans and equipment locations).
   - c. Emergency information on municipal utilities locations.
   - d. Command post communications for incident management teams.

## TABLE 28

## POTENTIAL APPLICATIONS OF COMMUNICATION AND COMPUTER TECHNOLOGIES IN SUPPORT OF TRAVEL ADVICE

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1. **ROAD MAP**
   - a. General road atlas:
     - — road network layout; and
     - — major attractions (categories selected by user).
   - b. Street name and route number and section length.
   - c. Facility type (limited access, toll, etc.) and terrain (grade).
   - d. Addresses (odd and even numbers for upcoming block and pinpoint location).
2. **TRAFFIC RULES**
   - a. Speed limits, parking and turn restrictions.
   - b. Weight limits, designated routes (for trucks and for dangerous goods), etc.
   - c. Snow clearance (days and sides of the street for parking), special event conditions.
3. **ROUTE GUIDANCE**
   - a. Circulation maps, etc.
   - b. Downtown exit guide (find open freeway entry ramps from anywhere).
   - c. En-route reception of InfoRoad, etc., and suggested route updates.
   - d. Trip computer (with planned vs. actual comparisons).
   - e. Traffic-responsive, dynamic advisory (reception, storage, display of traffic control centre signals).
4. **EMERGENCY RESPONSE**
   - a. Receive emergency broadcasts and store for reference as needed (such as for chemical spills, nuclear disasters, etc.).
   - b. Search and rescue missions in natural and man-made disasters (guidance to and around site).
   - c. Emergency CB (transmission of medical, mechanical and crime distress calls).
5. **PUBLIC SERVICE MESSAGES**
   - a. Road conditions due to weather.
   - b. Traffic and incidents (construction and maintenance closures, garbage disposal, emergency regulations).
   - c. General weather alerts (storms, floods, etc.).
   - d. Special events (content, location, times and parking).
   - e. Transit (route maps, next arrival based on bus line or stop code), park and ride (location, space available, charges).
   - f. Passenger and freight terminals (access, circulation, parking), carrier location and departures and arrivals.
   - g. Customs information (rules, line-ups, etc.).
   - h. Mobile billboard reception (drunk driving prevention program, etc.).
6. **ROADSIDE AND COMMUNITY SERVICES INFORMATION**
   - a. Adjacent land use and street block information.
   - b. Fuels and repair service, food and lodging, rest and picnic sites, parks, electronic bulletin board (community events, etc.).
   - c. Yellow pages by store type and product category (e.g. Telefind).
   - d. Distributors' lists of retailers for certain products.
   - e. Subject registers and company catalogues.
   - f. Videotex and mobile teleguide.
   - g. Shopping centre profiles (layout and store locations by type).
   - h. In-vehicle browsing of stores that sell through advertising by electronic means (viewing of liquid crystal price panels for daily specials, etc.).
   - i. Realty radio (property data sheets and floor plans).

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## TABLE 29

## POTENTIAL APPLICATIONS OF COMMUNICATION AND COMPUTER TECHNOLOGIES IN SUPPORT OF THE MOBILE OFFICE

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1. **WORD PROCESSING AND COMPUTING**
    - a. Commuter work stations (in car and van pools and subscription buses).
    - b. Word processing and memo pads.
    - c. Study periods (seminar tapes, etc.).
    - d. Calculator (four-function, business, engineering or scientific).
    - e. Compressed register by product category.
    - f. Manufacturers' lists of wholesalers and distributors.
    - g. Industrial sites reference catalogue (boundaries, leases and vacancies).
2. **COMMUNICATIONS**
    - a. Paging and messages transmission (company and personal).
    - b. Automatic dialing (customer orders).
    - c. Courier status.
    - d. Facsimile transmission and reception (and photophone still pictures).
    - e. Electronic bulletins (infloglobe, stock quotes).
    - f. Electronic Data Interchange (EDI).
    - g. Telemarketing, comprehensive client list (including personal data, etc.), customer, dealer, supplier locator (map location and postal code), daily diary, orders and follow-up call requests, electronic scratch pad (retrievable notes during phone calls).
3. **FREIGHT**
    - a. Electronically transmitted cargo routing slips (and wand for loading and unloading).
    - b. Freight:
        - — tariffs, rates and regulations;
        - — hazardous cargo (data base and emergency contacts and procedures); and
        - — in-vehicle stock control.
    - c. Terminals (locations, hours, personnel, line-up number and wait times).
    - d. Custom operations:
        - — hours, regulations, duties and location of clearance houses;
        - — Customs commercial system (CCS) (tariff classification); and
        - — Customs Automated Data Exchange (CADEX) (entry data to customs).
    - e. Motor carrier accident report:
        - — automatic entries (technical data); and
        - — preparation (manual input).
    - f. Travel expense recording (kilometres, time, fuel allocation and motel invoices).
    - g. Accounting (daily transactions).
4. **HOME BASE CONTROL**
    - a. Smart electronically controlled home:
        - — appliances (e.g. turn on before arrival), security, etc.;
        - — answering machine (message review and reset);
        - — etc.
    - b. Voice command system.

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# PART V

# PROPOSED OBJECTIVE AND SUB-OBJECTIVES OF TDC R&D PROGRAM IN HIGHWAY FREIGHT TRANSPORT TECHNOLOGIES

## BACKGROUND

Over the next 20 years, highway freight transportation technologies are expected to bring about the evolution and refinement of existing equipment, systems and infrastructure. The ability of Canadian companies to compete in world markets depends heavily on transportation costs. The proposed free trade agreement with the United States will increase competition between Canadian and American companies, making it necessary for Canadian companies to deliver their products as effectively and efficiently as their American counterparts. Because the Canadian gross national product (GNP) proportionally allocates 40% more than the U.S. to transportation, due to national territorial, environmental and population distribution factors, the Canadian transportation sector must find new and innovative ways to reduce costs.

The IBI Group Inc. economic analysis (22) conducted in conjunction with the RTAC/CCMTA weights and dimensions study clearly showed the net benefits to the Canadian economy that were possible by first increasing the volumetric capacity of commercial vehicles, and then increasing, to a lesser but still significant extent, the gross vehicle weight.

The introduction of longer and heavier trucks onto Canada's highways will, however, also increase the public's concerns about the safety of larger vehicles. American accident data (25) suggests that although heavy truck accident rates on an equivalent mileage basis are one-half those of passenger cars, the fatality rates for accidents involving heavy trucks are almost double. Even with the bias in commercial vehicle accident fatality rates heavily against the occupants of the other vehicle, driving a commercial vehicle is rated as one of the most hazardous occupations.

As a direct or indirect result of the RTAC/CCMTA weights and dimensions study, an awareness of the impact of heavy commercial vehicles has emerged in Canada. This awareness includes recognition of design parameters which affect dynamic performance, the impact heavy commercial vehicles have on the highway infrastructure, economic issues relating to vehicle capacity (both volume and weight), the relationship between dynamic performance and roadway design geometry, and the influence heavy commercial vehicles have on highway use and traffic flow. The RTAC/CCMTA study provided technical data on the relationship between design and performance and, perhaps more significantly, it highlighted the range of performance levels that are possible. We now know that it is economically possible, indeed practical, to operate vehicles with desirable dynamic performance characteristics.

As successful as the RTAC/CCMTA weights and dimensions study was, its findings were limited to four common interprovincial vehicle configurations, and its recommended design solutions were constrained by existing technologies or limited test data. The study identified measures that could be taken to improve the dynamic stability of commercial vehicles, but no study was done to determine which vehicle configurations have been involved in accidents due to their dynamic instability thresholds.

Safety and productivity improvements in highway transport are not mutually exclusive. In order to advance both safety and productivity, a cooperative and systematic approach to highway transport technologies must be taken by the federal and provincial governments, universities and other research agencies, the transportation industries and labour. It is in this cooperative spirit that TDC has developed, and intends to implement, its highway freight transport technology R&D program.

## PROGRAM DEVELOPMENT CONSIDERATIONS

In developing a proposal to TDC for an R&D program addressing highway freight transport technologies, it was necessary to consider the perceived opportunities for R&D in the context of federal government and Transport Canada priorities, as well as the R&D mandate given to TDC. For purposes of this report, these are summarized in Table 30. It was also necessary to consider federal responsibilities in highway transportation, which are listed in summary form in Table 31. Finally, a great deal of consultation was undertaken with other federal departments, provincial governments, industry and industry associations.

## PROPOSED PROGRAM OBJECTIVE

"To undertake and promote cooperative research, development and demonstrations relating to the safety, productivity and operation of commercial vehicles, their effects on roadways, the transportation of dangerous goods, energy efficiency, and alternative fuels."

TABLE 30

**FEDERAL PRIORITIES AND TDC MANDATE**

**FEDERAL GOVERNMENT AND DEPARTMENTAL PRIORITIES**

1. Improve transportation safety and security including improved measures for the transportation of dangerous goods.
2. Stimulate and support national and regional economic development.
3. Promote improved efficiency and productivity.
4. Reduce energy requirements and promote efficient use of national resources.
5. Undertake and stimulate effective R&D.
6. Stimulate international trade.
7. Develop alternative investment strategies.
8. Preserve useful national infrastructure investment.

**TDC R&D MANDATE**

1. Support departmental needs.
2. Support federal government priorities.
3. Support innovation in the transport community.
4. Coordinate departmental and broader R&D activities.

## PROPOSED PROGRAM SUB-OBJECTIVES

Concurrent sub-objectives were also proposed for this program. They are as follows.

1. To develop data-gathering technology and systems to support the corporate need for meaningful heavy truck exposure and accident data.
2. To facilitate the systematic assessment and diffusion of new developments in highway freight transport technology.
3. To advance research into highway freight transport technologies relating to vehicle safety and productivity.
4. To advance research into the interaction between highway freight vehicles and roadways and its effects on vehicle design.
5. To stimulate applications of technology and enhancement of existing technology to improve the performance and productivity of compliance techniques that support national regulations.
6. To investigate advanced technologies for improved operations in the highway transport sector, and related human factors, to assist Canadian transportation industries operate more safely and efficiently, and keep pace with emerging technologies.

A summary of the objective and sub-objectives is provided in Table 32.

## CONCLUSION

There are many and varied R&D opportunities available for advancing highway freight transport. These touch upon virtually every facet of the industry and will ultimately determine its economic position vis-à-vis the competing modes as well as the public's acceptance of an increasing role for the industry on the nation's road network.

With the limited funds available to the Transportation Development Centre to address highway freight transport R&D, its emphasis will be upon those areas that support Transport Canada's mandate in highway transportation. It will be the responsibility of the highway transportation community at large to make the greater vision of a highway transportation system of the future a reality.

## TABLE 31

## FEDERAL RESPONSIBILITIES IN HIGHWAY TRANSPORTATION

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**DIRECT**

1. Vehicle safety regulation.
    a. Regulation of new vehicles and tire design and manufacture.
    b. Requirements for correction of safety defects.
2. Regulation of transportation of dangerous goods.
3. Regulation of extraprovincial motor carrier transport.
4. R&D in support of Transport Canada's mandate in highway transportation.
5. Highway/railway safety and level crossing protection program.
6. Highway safety educational programs.
7. Construction and maintenance of roads on federal property.
8. Federal support to provinces for specific road construction projects.
9. Federal support for road safety projects.
10. Bridges over navigable waters.
11. Highway motor vehicle and criminal code enforcement in several provinces.

**INDIRECT**

1. Free trade and international use of highway system.
2. Department of defense and strategic use of highway system.
3. Membership: Council of Ministers of Transportation and Highway Safety.
4. Membership: Canadian Council of Motor Transport Administrators.

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## TABLE 32

## TDC'S HIGHWAY FREIGHT TRANSPORT TECHNOLOGY R&D PROGRAM

### PROPOSED OBJECTIVE

"To undertake and promote cooperative research, development and demonstrations relating to the safety, productivity and operation of commercial vehicles, their effects on roadways, the transportation of dangerous goods, energy efficiency, and alternative fuels."

### PROPOSED SUB-OBJECTIVES

| TYPE | INTENTION |
|---|---|
| 1. Exposure and accident data methodology (data gathering technology and systems) | Long-Term:<br>Support corporate regulatory and operational needs. |
| 2. Technology assessment and diffusion | Exploratory:<br>Identify innovations with potential to improve transport system elements. |
| 3. Vehicle technology research<br>4. Infrastructure impacts research<br>5. Compliance technology research<br>6. Operational technology research | Sector-Directed:<br>Support innovations in transportation sector.<br>— Safety<br>— Productivity<br>— Energy<br>— Dangerous goods<br>— Environmental<br>— Carrier operations<br>— Driver performance |

# APPENDIX A

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# APPENDIX B

# 1988-89 TDC OPERATIONAL PLAN RELATING TO HIGHWAY TRANSPORT

Highway ........ B-3

Urban ........ B-9

Transportation for the Elderly and the Disabled ........ B-11

Canada-Quebec ERDA Transportation Sub-Agreement ........ B-14

## HIGHWAY

Although it falls mainly under provincial government jurisdiction, the highway transportation mode is by far the most dominant and most important mode in Canada. The TDC program of highway R&D is based on the following four justifications:

- specific federal regulatory responsibilities such as the transportation of dangerous goods;
- general federal responsibilities under the National Transportation Act for safe and efficient highway transportation;
- the application of R&D to highway problems of national importance, such as heavy vehicle safety, stability and productivity and road maintenance costs;
- as a means to achieve other federal objectives related to energy conservation and substitution, national science policy, regional economic development, transportation for the elderly and the disabled, and industrial development.

The highway R&D program is a selective one, stressing cooperative research with provincial governments and the private sector to foster a co-ordinated national approach to highway R&D and reduce total system costs. Parts of the program reflect current concerns about the competitive position of the Canadian trucking industry and, by extension, all Canadian industry given the prospect of free trade with the United States.

Safety R&D initiatives undertaken within the highway program are normally combined with other transportation objectives such as productivity improvements, in an effort to encourage voluntary adoption of safety measures by industry. This approach is viewed as a complementary and limited alternative to regulating safety measures.

The department's R&D policy emphasizes the importance of exploratory transportation R&D. It is estimated that in this first year of application of the new policy, 20 per cent of TDC's highway program will consist of exploratory R&D. This will rise to 35 per cent over the next three years.

Also reflecting the new R&D policy, funding sources for the 1988-89 fiscal year are somewhat altered from those of the 1987-88 fiscal year (see Figure 9).

The structure of this year's operational plan is different from that of previous years. As a consequence, a major $1.333 million intercity bus demonstration program is described in a separate section of the operational plan devoted to the Canada-Quebec ERDA (see page 93). The structure of the highway program has also been altered and therefore a comparison of highway R&D thrust areas with those of 1987-88 is not possible.

## 1. Highway Infrastructure (H100)

**Objective**

Undertake a selective research program in highway infrastructure that promotes a co-ordinated national approach, complements the initiatives of other actors and contributes to the attainment of federal government transportation and other objectives.

**Sub-Objectives**

### 1.1 cooperative National Programs (H110)

Undertake cooperative research with provincial governments and with the Roads and Transportation Association of Canada addressing the design, construction, maintenance, renovation and operation of Canada's highway system in order to reduce total system costs.

**Current Targets**

Participate in the Canadian Strategic Highway Research Program (C-SHRP).

Complete the project on the control of drifting snow.

### 1.2 Weigh-in-Motion, Vehicle Classification and Pavement Testing Equipment (H120)

Facilitate the effective management of heavy vehicles and the highway system through the development of innovative electronics-based equipment for axle load measurement, vehicle classification and pavement testing.

**Current Targets**

Complete the low cost weigh-in-motion scale and vehicle classification project.

Complete the high precision weigh-in-motion scale project.

Undertake a technology assessment of pavement testing equipment.

## 2. Highway Vehicle Research (H200)

**Objective**

Encourage the development of safer, more productive and more efficient heavy vehicles.

**Sub-Objectives**

### 2.1 Freight Vehicles (H210)

Promote the design and manufacture of safer, more productive and more efficient semi-trailers, straight trucks, and specialty vehicles through the use of computer-aided design, new materials and the adoption of voluntary safety measures.

### Current Targets

Initiate a feasibility study of an advanced pulpwood trailer incorporating improved suspension, reduced tare weight, load measurement and display system.

Investigate the feasibility of developing an advanced design semi-trailer incorporating novel safety features and productivity improvements.

Continue the development and verification of a more stable liquid tanker together with a visual demonstration of liquid slosh behaviour.

## 2.2 Passenger Vehicles (H220)

Promote the design and manufacture of safer, more accessible, more productive, and more comfortable buses through the application of computer-aided design, the use of new materials and technology transfer from more sophisticated transportation modes.

### Current Targets

Continue the development of the 45-foot accessible bus.

Demonstrate improved air quality on buses through the design of an improved heating, ventilating and air-conditioning system with Prévost Car Inc.

Calibrate and test the bus suspension system model with Prévost Car Inc.

## 2.3 Heavy Vehicle Dynamics (H230)

Undertake theoretical studies and encourage the design and manufacture of innovative hitches, axles and other devices contributing to better heavy vehicle stability and safety.

### Current Targets

Undertake a technological survey to assess the need for, and feasibility of, an expert system for analysis of vehicle dynamic stability. Develop a long-term program in this area.

Undertake a technology survey to develop an improved self-steering axle to reduce the need for lift axles under loaded trailer conditions.

## 2.4 Heavy Vehicle Braking (H240)

Develop equipment and procedures that encourage better brake design, operation and maintenance through the application of advanced micro-electronics and computer software.

### Current Target

Initiate the design phase for a Canadian application of anti-lock brakes.

## 2.5 Heavy Vehicle Active Suspensions (H250)

Encourage the design of heavy vehicle suspension systems, with improved stability, ride quality, and road damage characteristics while contributing to the eventual development of a heavy vehicle active suspension.

**Current Target**

Prepare a long-term program and initiate one project in this area.

## 3. Vehicle Systems (H300)

**Objective**

Encourage the development of vehicle-related equipment and systems to improve the safety, productivity and efficiency of highway transportation.

**Sub-Objectives**

### 3.1 Driver Safety Aids (H310)

Encourage the development of devices that promote safe driving.

**Current Targets**

Undertake a technology survey of roll-over threshold alarm systems, assess the feasibility of developing an effective device, and plan the development phase of the device.

Undertake a technology survey of driver training simulators, assess the needs and the required technology, assess the feasibility of developing an effective interactive simulator and plan the stimulator development phase.

### 3.2 Vehicle Electronics (H320)

Contribute to highway safety and productivity through the development of vehicle-based electronic and communication systems such as vehicle location, identification and control systems, vehicle navigation systems, and on-board data acquisition systems.

**Current Targets**

Continue to develop a cellular radio location system.

Continue the investigation of different navigation technologies and their potential applications in transportation.

Develop a rugged data acquisition system based on the new Institute of Electrical and Electronic Engineers (IEEE) vehicle on-board communication standards.

Develop a reliable tractor/trailer electronic connector and multi-plexing system.

Undertake a technology assessment of the impact of on-board navigation systems on traffic signal control and automated highway development.

### 3.3 Transportation of Dangerous Goods (H330)

Develop methods, designs and procedures for the safer and more efficient transportation of dangerous goods.

**Current Targets**

Undertake a technology assessment of electronics-based ways to improve dangerous goods transportation, such as electronic licence plates, electronic log books and bills of lading.

Continue the demonstration of an expert system-based dispatching system.

Continue the development of acoustic emission methodology applied to high-pressure tubes and fibreglass reinforced plastic tankers for non-destructive testing of dangerous goods containers.

### 4. Energy Conservation and Substitution (H400)

**Objective**

Undertake highway projects which contribute to government objectives with respect to energy conservation and the use of alternative fuels.

**Sub-Objectives**

#### 4.1 Energy Conservation (H410)

Provide a better understanding and technology improvements to the components and environment affecting energy conservation in highway transportation.

**Current Targets**

Continue tribology research to improve the understanding of energy losses in the engines and drive-trains of heavy vehicles.

Continue work on the vehicle/road/driver/environment cross-impact on energy consumption. Develop a theoretical model and calibrate it with appropriate testing.

Continue work on energy-efficient transportation of perishable goods by completing development of the $CO_2$ refrigeration project. Evaluate results and review requirements for a demonstration or other further work.

#### 4.2 Alternative Fuels (H420)

Provide a better understanding and technology improvements to the components and environment affecting the use of alternative fuels in highway transportation.

**Current Target**

Continue work on propane in diesel engines and initiate methanol emissions research for diesel engines.

### 5. Technology Transfer and Program Planning (H500)

**Objective**

Maximize the benefits of TDC's highway R&D by undertaking selected activities designed to provide effective technology transfer and program planning.

**Sub-Objectives**

5.1 **National and International Information Exchange (H510)**

Facilitate the exchange of information on highway R&D by organizing conferences and seminars on national and international levels.

**Current Target**

Participate in selected seminars and conferences.

5.2 **Program Planning (H520)**

Provide technical investigation and engineering services in support of planning and implementation of new R&D initiatives.

**Current Targets**

Evaluate the state-of-the-art technologies and adjust the long-term research program accordingly.

Provide additional technical expertise in support of current highway passenger and freight R&D activities.

## URBAN

Although urban transportation is primarily the concern of provincial and municipal governments, the technology base and the issues of energy efficiency, safety and accessibility are of national interest, calling for some federal contribution. In 1985, Transport Canada granted the Canadian Urban Transit Association (CUTA) $64,000 annually for five years to co-ordinate urban transportation R&D. In 1988, as a result of the Transport Canada's new R&D policy, TDC's urban transportation R&D, in areas where it qualifies for core funding, is expected to increase. There will continue to be projects conducted under federal-provincial ERDAs or memoranda of understanding, and energy-related projects eligible for funds from the energy R&D program of EMR.

The largest sector of TDC's urban R&D activity in 1988-89 addresses transit/traffic technologies. Vehicle and battery technology R&D is expected to reverse its declining trend as the result of EMR funding support of projects to develop advanced molybdenum and aluminum/air batteries.

The future outlook for TDC's urban R&D program indicates the prime emphasis will be on exploratory and technology assessment activities relating to urban vehicle location, identification and control using micro-electronics and expert systems.

### Objective (U100)

Support R&D projects that contribute to government objectives, such as energy conservation, safety, oil-use reduction, and industrial development, and maintain a watching brief on urban transit and traffic technology developments.

### Sub-Objectives

### 1. Support the Development of Transit and Traffic Technologies (U111)

Support and evaluate developments in innovative transit and traffic technologies aimed at increasing efficiency, safety and energy conservation.

**Current Targets**

Complete vehicle diagnostic study with the province of Ontario.

Develop, manufacture and install a Ker-Train binary logic incrementally variable transmission in an urban bus.

Explore implementation of Integrated Transportation Information System (ITIS) applications for urban transit.

Maintain a watching brief on vehicle location, identification and control systems for urban transit.

### 2. Urban Transportation Energy Management (U112)

Conserve oil-based fuels through better system management techniques and use of micro-electronic control technology.

**Current Target**

Complete the integrated micro-computer traffic analysis system demonstration project with the province of Ontario.

### 3. Vehicle and Battery Technology (U113)

Reduce Canada's current dependence on petroleum-based fuels through the development of micro-vehicles, electric vehicles and batteries. (Fuel substitution for road vehicles is dealt with in the highway R&D program; see page 53).

**Current Targets**

Develop Li Mo S2 "F" cell battery with NRC for future application in electric vehicle systems.

Develop mobile platform using aluminum/air batteries and the BC Hydro new motor for the advanced electric wheelchair.

Complete a study to identify opportunities for the application of advanced batteries by Transport Canada.

### 4. Technology Assessment, Transfer and Support (U114)

Maintain a base of expertise, establish data files and disseminate information, as required by the federal government, relating to urban transportation technologies and their application.

**Current Targets**

Assist CUTA in activities relating to automatic vehicle location and control.

Maintain a watching brief on people-mover technologies, urban trucking technologies, on-board navigation systems, etc.

## TRANSPORTATION FOR THE ELDERLY AND THE DISABLED

Transport Canada supports a multimodal R&D program aimed at improving transportation accessibility for the elderly and the disabled. In keeping with the 1984 federal policy on transportation of disabled persons calling for development of accessibility standards for all modes of transportation under federal jurisdiction, the department has set up the Transportation of Disabled Persons Implementation Committee, whose mandate includes recommending R&D directions. This committee has expressed particular interest in intercity bus accessibility and communication aids for people with visual and hearing impairments.

TDC's operational plan responds to the priorities established by this committee. TDC expects to obtain about $1 million in 1988-89 from the Transportation of Disabled Persons Program (TDPP), a four-year (1985-86 to 1989-90), $8-million program approved by the Cabinet Committee on Economic and Regional Development in 1985.

TDC's R&D program is aimed at developing technology to improve the safety and accessibility of transportation systems for elderly and disabled Canadians, with the focus on transportation modes under federal jurisdiction. The current emphasis is on improving the accessibility of aircraft and intercity buses.

Safety projects are also being identified and initiated. R&D into micro-electronic and communication technology for the perceptually and sensory impaired is expected to increase significantly in the future.

While the 1988-89 TDC R&D program relies heavily on TDPP funding, it is expected that a gradual shift from TDPP to TDC base funding will occur. The principal thrust of this year's program is vehicle accessibility, as illustrated in Figure 14.

### Objective (E100)

Foster the development of technology in the form of equipment, systems and procedures to enable elderly and disabled persons to access transportation services in Canada, with particular emphasis on federally regulated modes.

### Sub-Objectives

### 1. Accessibility of Vehicles (E110)

Aid in the development and evaluation of accessible vehicles and transit services, including automobiles, commuter rail, buses, aircraft, ferries and transfer vehicles.

#### Current Targets

Complete the evaluation of the prototype multi-purpose vehicle in demonstration service in Manitoba.

Complete work transferring elevator-lift technology to the Prévost Mirage XL coach.

Undertake an accessible taxi demonstration with province of Ontario.

Initiate the accessible bus demonstration with Canada Coach Lines.

2. **Level Change Technologies (E120)**

Evaluate and develop appropriate technologies to overcome the problem of level change for the disabled, especially wheelchair users.

**Current Targets**

Complete the demonstration and evaluation of selected aircraft boarding systems.

Complete work on the accessibility of small aircraft.

Implement the design, development and evaluation of selected station-based bus boarding systems.

3. **Safety (E130)**

Improve the safety of elderly and disabled travellers in vehicles, terminals and ways.

**Current Targets**

Continue the development of wheelchair securement systems.

Develop standards for transportable wheelchairs.

Develop a method to quantify unsafe incidents involving elderly and disabled travellers.

Perform a national survey of driver licensing criteria and their implications for the elderly and the disabled.

4. **Elimination of Travel Barriers (E140)**

Eliminate travel barriers for the elderly and the disabled in all modes and develop alternative designs or procedures facilitating travel.

**Current Targets**

Investigate signage and tactile aids for the perceptually and sensory impaired.

Further develop computerized scheduling system in Vancouver using an expert system.

Complete the development of Communicaid II and the portable communicator.

Initiate problem definition studies relating to the mentally disabled.

5. **Technical Aids (E150)**

Develop technical devices to assist the elderly and the disabled to overcome interface problems in terminals and vehicles.

**Current Targets**

Complete the development of a driving simulator.

Implement an automated telephone assistance system for use in transit services for the disabled.

Explore computer-aided design technology as design tools for the elderly and the disabled (e.g. electronic design template).

### 6. Database Development (E160)

Establish a database on elderly, disabled and cognitively impaired Canadians, not covered by Statistics Canada or other databases.

**Current Targets**

Continue to integrate data from the Canadian Health and Disability Survey (Labour Force Survey) to build a complete database on elderly and disabled Canadians.

Develop predictive models on trip-making behaviour of the elderly and the disabled.

### 7. Wheelchair R&D (E170)

Improve the safety, comfort, economy and portability of wheelchairs.

**Current Target**

Complete development of the prototype advanced-design wheelchairs and perform ergonomic and technical evaluations.

### 8. Technology Assessment, Transfer and Support (E180)

Assess and support the planning of R&D activities and disseminate information to a wide audience of researchers, service providers, policy-makers and consumers.

**Current Targets**

Participate in conferences, workshops and exhibits, and organize seminars on personal mobility.

Implement TIES and disabled consumer consultation contracts.

Initiate study on information system analysis.

## CANADA-QUEBEC ERDA TRANSPORTATION SUB-AGREEMENT

In December 1984, the federal government and the province of Quebec signed an Economic Regional Development Agreement (ERDA). In July 1985 the two governments signed a $170 million ERDA sub-agreement on transportation development that includes $15 million over five years for transportation R&D.

Briefly stated, the objectives of the research and development program of the sub-agreement are: to increase transportation R&D in Quebec; to strengthen the transportation equipment manufacturing sector in Quebec, and to increase the productivity, the competitiveness and technological development of the Quebec transportation system. Projects are funded equally by both governments, must meet the objectives of the sub-agreement in the sectors specified by it and must be acceptable to both governments.

The four sectors covered by the program are road transportation, rail transportation, microelectronics and computers, and intermodal transportation.

A major ERDA achievement was marked in October 1987 with the signing of an agreement between Voyageur Inc. and the two governments for a two-year bus demonstration using new Canadian bus technology.

During 1988-89, in addition to the bus demonstration, work will continue on the development of a fabricated rail-car truck and the production of a longer subway car.

Negotiations will be undertaken with Quebec to initiate new projects in several areas including advanced train control and road safety. A concerted effort will be made, in conjunction with Transports Quebec, to fully commit all remaining R&D funds.

# APPENDIX C

# PROPOSED 1989-90 TDC OPERATIONAL PLAN RELATING TO HIGHWAY TRANSPORT

Highway ........ C-3

Transportation for Elderly and Disabled Persons ........ C-9

Multimodal ........ C-14

# HIGHWAY TRANSPORTATION

The highway system is the backbone of the country. Most goods and people travel on highways. However there is no single agency responsible for highway freight transportation in Canada. A cooperative approach among governments at all levels is necessary if progress is to be made in adapting new technologies to highway operations. Future scenarios may include computers, communications or other electronic systems generating an electronic highway that links driver, vehicle and roadway through a vast distributed network that provides selectable control, vehicle guidance and advisory functions.

The TDC Highway Transportation R&D Program stresses co-operative research with the provinces and the private sector to foster a co-ordinated, cost-effective national approach to highway R&D. TDC acts as a catalyst in trying to have the issues addressed by all concerned, highway and trucking associations, motor carriers, manufacturers, and various government jurisdictions. Programs are funded mainly from TDC's base budget with funding also being provided by the Energy R&D Panel.

## 1. Infrastructure (H100)

### Objective

To undertake a selective research program in highway infrastructure which complements the initiatives of other actors and contributes to the achievement of federal government transportation objectives. The program is designed to promote a co-ordinated national approach to all research activities.

### Sub-Objective

### 1.1 Co-operative National Programs (H110)

To undertake co-operative research with the provinces and with the Roads and Transportation Association of Canada which addresses the design, construction, maintenance, rehabilitation and operation of Canada's highway system in order to minimize total system costs.

#### Current Targets

Participate in the Canadian Strategic Highway Research Program C-SHRP).

Complete the project on the control of drifting snow.

## 2. Truck Technology (H200)

### Objective

To undertake research, development and demonstrations relating to safety or productivity of freight vehicles, or their operation, including the transportation of dangerous goods, energy efficiency and use of alternative fuels.

### Sub-Objectives

### 2.1 Transportation of Dangerous Goods (H210)

To develop methods, designs and procedures to improve the level of safety in the transportation of dangerous goods within an economically efficient and competitive market.

#### Current Targets

Complete the prototype development of an expert system to interpret dangerous goods regulations and to provide advice on placarding and documentation.

Continue the investigation of steel and composite materials for use in natural gas vehicle cylinders and undertake the development of acoustic emission testing techniques.

Complete the liquid tanker stability program including computer model development of liquid slosh behaviour. Validate the liquid sloshing computer model through instrumented field tests.

Develop the program terms-of-reference and initiate a project for a field communications system for use in dangerous goods accidents.

### 2.2 Heavy Vehicle Safety Technology (H220)

To advance research into highway freight transport technologies, methodologies for exposure data collection, and human factors that will assist in improving the safety of highway vehicle transportation.

#### Current Targets

Determine the feasibility of an anti-jackknife system incorporating automatic fifth wheel braking. Complete development and laboratory test of a working prototype. Initiate field test of the prototype.

Initiate a program for evaluation of technology options for exposure data collection.

Initiate a project for the development of an electronic log book, an ERDA project.

Initiate a program for the development of an expert system for the analysis of vehicle dynamic stability.

Initiate a program to optimize the safety and effectiveness of trailer lift axles.

Assess the needs and the required technology for a driver training simulator, assess the feasibility of developing an effective simulator and initiate the development of a driver simulator.

Undertake a technology survey of roll-over threshold alarm systems, assess the feasibility of developing an effective device and plan the development phase.

Initiate a program for the development of a heavy vehicle active suspension.

### 2.3 Heavy Vehicle Compliance Technology (H230)

To stimulate applications of technology that will improve the accuracy and productivity of compliance techniques needed to monitor national regulatory requirements.

**Current Targets**

Complete the state-of-the art review of technologies suitable for use in developing a low-cost, low-maintenance, on-board truck scale system. Undertake the design, build and initial test of the most promising systems. One system to be an ERDA project.

Fully define the program requirements and initiate a program of Canadian participation in the American "Heavy Vehicle Electronic License Plate" (HELP) Program.

Investigate the feasibility of a remote automatic weigh-in-motion station and, if practical, initiate a project.

### 2.4 Transportation System Efficiency & Productivity (H240)

To encourage the development of vehicle related equipment and systems which improve the efficiency and productivity of highway transportation; to keep pace with emerging technologies.

**Current Targets**

Complete the state-of-the-art review of vehicle electronic technology. Review the results and develop a long-term program for the most suitable activities in this area.

Continue the evaluation of potential gains achievable by using tridem axles on logging trucks.

Continue the evaluation of the cellular radio location system.

Complete the development and demonstration of the expert system based dispatching system.

Initiate a program to develop a reduced axle weight salt spreader, an ERDA project.

Complete the program terms of reference for the investigation of vehicle design effects on pavement performance and initiate the project.

Fully define the program requirements to develop an advanced truck design simulator and initiate the project.

## 2.5 Energy Conservation and Substitution (H250)

Provide a better understanding and technology improvements to the components and the environment affected by energy conservation and the use of alternative fuels in highway transportation.

**Current Targets**

Continue tribology research to improve the understanding of energy losses in the engines and drive-trains of heavy vehicles.

Continue work on the vehicle/road/driver/environment cross-impact on energy consumption. Develop a theoretical model and calibrate it by appropriate testing.

Initiate a project on the evaluation of a system to reduce the nitric oxides in diesel exhaust. Complete the laboratory test-cell set-up and the single cylinder tests.

Initiate a project on the evaluation of diesel emissions from methanol fuel. Complete the laboratory test-cell set-up and the single cylinder tests.

### 3. Bus Technology (H300)

**Objective**

To encourage the development of safer, more productive and more efficient buses.

**Sub-Objectives**

#### 3.1 Intercity Bus Highway (H310)

To promote the design and manufacture of safer, more accessible, more productive and more comfortable buses through the application of computer aided design, the use of new materials, and technology transferred from more sophisticated areas.

**Current Targets**

Evaluate the results of the first 12 month's Voyageur articulated bus demonstration and determine the level of service to be offered in the second year of operation, ie., number of vehicles, seat layout.

Complete the design, fabrication and testing of a fully equipped prototype accessible 45-foot inter-city bus.

Determine the feasibility of implementing multiplexing to buses. Develop detailed requirements for applying a prototype system to a vehicle.

Undertake further investigation of advanced bus suspension concepts using the UTDC computer simulation model.

### 4. Technology Evaluation & Transfer (H400)

**Objective**

To maximize the benefits of TDC's highway R&D by undertaking selected activities designed to provide effective technology transfer and program planning.

**Sub-Objectives**

#### 4.1 Technical Support (H410)

To provide technical investigation and engineering services in support of planning and implementation of new R&D activities; and, to facilitate the exchange of information on highway R&D by organizing conferences and seminars on national and international levels.

## Current Targets

Evaluate state-of-the-art technologies and adjust the long-term research program accordingly.

Provide additional technical expertise in support of current highway transportation R&D activities.

Participate in selected seminars and conferences.

## TRANSPORTATION FOR ELDERLY AND DISABLED PERSONS

Transport Canada supports a multimodal R&D program aimed at improving transportation accessibility for the elderly and the disabled. In keeping with the 1984 federal policy on transportation of disabled persons calling for development of accessibility standards for all modes of transportation under federal jurisdiction, the department has set up the Transportation of Disabled Persons Implementation Committee, whose mandate includes recommending R&D directions. This committee has expressed particular interest in aircraft and intercity bus accessibility, as well as communication aids for people with visual and hearing impairments.

TDC's operational plan responds to the priorities established by this committee. TDC expects to obtain about $1 million in 1989-90 from the Transportation of Disabled Persons Program (TDPP), a four-year (1985-86 to 1989-90), $8-million program approved by the Cabinet Committee on Economic and Regional Development in 1985.

### 1. System Accessibility (E100)

**Objective**

To foster the development of technology in the form of equipment, systems and procedures to enable elderly and disabled persons to access transportation services in Canada, with particular emphasis on federally regulated modes.

**Sub-Objectives**

### 1.1 Aircraft & Airports (E110)

To aid in the development and evaluation of accessible aircraft, transfer vehicles, and terminals with emphasis on level change technologies.

**Current Targets**

Complete the demonstration and evaluation of selected aircraft boarding systems.

Initiate Phase II development work on the accessibility of small aircraft.

Continue assessment of in-flight wheelchair storage unit.

### 1.2 Marine Vessels (E120)

To aid in the development and evaluation of accessible ferries.

**Current Target**

Continue vessel accessibility project.

### 1.3 Intercity Bus (E130)

To contribute to the improvement in equity and accessibility of the transportation services provided by intercity buses.

**Current Targets**

Implement the design, development and evaluation of selected station-based bus boarding system.

Continue the accessible bus demonstration with Canada Coach Lines (CCL).

Initiate a long-term demonstration of fully-integrated, accessible bus service on CCL's main corridor through Hamilton, Ontario.

### 1.4 Access/Egress Modes (E140)

To aid in the development and evaluation of accessible vehicles and transit services including automobiles, taxis etc.

**Current Targets**

Implement accessible taxi demonstrations with the province of Ontario and as an ERDA project.

Initiate follow-on improvements to the multipurpose vehicles.

Perform paratransit driver task analysis.

Assess the applicability of zero-force controls for handicapped drivers.

## 2. Safety for E&D Passengers (E200)

### Objective

To improve the safety of elderly and disabled travellers in vehicles, terminals and ways.

### Sub-Objectives

### 2.1 Wheelchair Passenger (E210)

To minimize the inconvenience and risk of travelling for wheelchair passengers.

**Current Targets**

Complete the development of wheelchair securement systems.

Complete the development of a standard wheelchair interface system.

Define study terms of reference for testing crashworthiness of wheelchairs.

Initiate study to develop standards for transportable wheelchairs.

### 2.2 Elderly Drivers and Pedestrians (E220)

To enhance the safety of elderly drivers and pedestrians through adaptations of new and existing technology.

**Current Targets**

Investigate methods to improve the safety of elderly drivers and pedestrians.

Implement a study to quantify unsafe incidents involving elderly and disabled travellers.

## 3. Communication & Orientation (E300)

**Objective**

To eliminate travel barriers for the elderly and the disabled in all modes and develop alternative designs or procedures facilitating travel with emphasis on communication/orientation systems.

### 3.1 Visually/Hearing Impaired (E310)

To facilitate travel for visually/hearing impaired travellers through adaptation of new and existing technology.

**Current Targets**

Complete the evaluation of Communicaid II and the portable communicator.

Investigate signage and tactile aids for the perceptually and sensory impaired.

### 3.3 Cognitively Impaired (E320)

To facilitate travel for cognitively impaired travellers through adaptations of new and existing technology.

**Current Targets**

Continue study on problem definition relating to the cognitively impaired.

Implement an automated telephone assistance system for use in transit services for the disabled.

## 4. Technology Development & Transfer (400)

**Objective**

To assess and support the planning of R&D activities and disseminate information to a wide audience of researchers, service providers, policy-makers and consumers.

**Sub-Objectives**

### 4.1 Enabling Technologies & Disciplines (E410)

To investigate methods and technologies to enable increased levels-of-safety for elderly and disabled travellers, pedestrians and drivers.

**Current Targets**

Assess and develop warning and evacuation systems for disabled persons.

Initiate the development of the assessment module of a driving simulator.

Complete study on information system analysis.

### 4.2 Technology Support/Information Transfer (E420)

To assess and support the planning of R&D activities and to disseminate information to a wide audience of researchers, service providers, policy-makers and consumers.

**Current Targets**

Participate in conferences, workshops and exhibits, and organize seminars on personal mobility.

Implement TIES and disabled consumer consultation and communication support contracts.

Continue to integrate data from the Canadian Health and Disability Survey (Labour Force Survey) to build a complete database on elderly and disabled Canadians.

## MULTIMODAL

Transportation presents many challenges as well as opportunities for improvement when considered systematically, particularly when the system involves interfaces between modes or factors applicable to several modes, enabling disciplines and technologies (e.g. ergonomics, AI/Expert Systems/CAD, etc.). Multimodal studies invariably involve many actors drawn from the private and public sectors, from various levels of government, and from various disciplines, all of whom work together to reach consensus on research requirements and project implementation. The multimodal program is an amalgamation of a number of R&D areas in the previous Operational Plan such as Urban, Off-Road and Solids Pipeline and Tracked Levitated Vehicles. The program includes projects funded by multiple sources.

A new element in this program is the Visiting Experts Program which involves having outside experts as advisors and researchers at TDC for periods of up to six months on strategic areas of transportation R&D.

### 1. Energy (I100)

#### Objective

To improve safety, efficiency, and overall effectiveness of the transportation system through exploratory research and development, including that relevant to enabling disciplines, technologies, and analytical methodologies (e.g. ergonomics, AI/Expert Systems/CAD, MEG, etc.), that apply to more than one mode of transport.

#### Sub-Objectives

#### 1.1 Urban Transport Energy Management (I110)

To conserve and to reduce oil-based fuels through better urban transportation system management techniques; and to reduce dependance through the development of more efficient vehicle technology and alternative fuels.

#### Current Targets

Complete development and initial training to municipalities on the integrated micro-computer traffic analysis system demonstration project with the province of Ontario.

Complete trials of a Ker-train binary topic incrementally variable transmission in an urban bus.

Initiate investigations into natural gas for transit vehicles, an ERDA project.

Develop a road vehicle counter, an ERDA project.

Complete development of a generic, high-capacity subway car body, an ERDA project.

## 2. Technology Transfer (I200)

### Objective

To maintain and enrich TDC's technical base of expertise and to promote transfer of knowledge from enabling disciplines to transport applications through seminars, personnel exchanges, symposia and workshops.

### Sub-Objectives

### 2.1 Visiting Experts Program (I210)

To implement and maintain a visiting experts program at the Transportation Development Centre on a three-year trial basis from April 1, 1989 to March 31, 1992.

**Current Targets**

Implement the program and establish procedures for identifying, approving and contracting with appropriate candidates.

Contract with at least four persons as visiting experts during FY 1989/90.

### 2. Technology Seminars & Workshops (I220)

To organize technical seminars and workshops on technology issues and disciplines relevant to more than one mode of transport.

**Current Targets**

Organize a seminar on simulator ergonomics.

Organize a seminar concerning the human factors influencing safety: railway locomotive and truck operation.

## 3. Technology Monitoring (I300)

To monitor developments in transport technologies where Transport Canada does not currently have a direct responsibility but which are considered of possible future importance to the Department The intention is to understand the environmental, safety, productivity and cost-effectiveness of these systems so as to advise Transport Canada regarding policy issues.

**Sub-Objectives**

### 3.1 Transit and Traffic Technologies (I310)

To monitor developments in transit and traffic technologies in collaboration with CUTA and other organizations involved in this area.

**Current Targets**

Maintain liaison with CUTA to identify joint projects in urban transit.

### 3.2 Non-Conventional Transportation Systems (I320)

To monitor developments in non-conventional transportation systems so as to understand their potential impact, and to evaluate applications of appropriate technologies in Canada.

**Current Targets**

Maintain a watching brief on maglev transportation systems, off-road transport technology and solids pipelines.

Renew agreement with NRC for joint efforts on superconductivity and maglev transport systems.

Investigate coal transfer by liquefaction.

Establish capability to address environmental R&D requirements.

## 4. Emerging Technologies (I400)

To undertake long term development of key emerging technologies which have the potential for enabling major improvements to the transportation system in Transport Canada's operations.

**Sub-Objectives**

### 4.1 Satellite Location & Navigation (I410)

To undertake developments in satellite locations and navigation which respond to specific Canadian transportation requirements.

**Current Targets**

Continue development of a dual-frequency, multichannel Global Positioning System engineering receiver capable of tracing the carrier of the military frequency without access to the military code, in order to enable Transport Canada studies on ionospheric disturbances to GPS in northern Canada.

Initiate development of a 406 MHz location beacon compatible with COSPAS/SARSAT.

Complete the review of all radio-navigation and location systems in Canada for surface transportation in preparation for a multimodal review, and initiate multimodal review.

## 4.2 Monolithic Microwave Integrated Circuits (MMIC) (I420)

To undertake a multi-year development program to establish a capability in Canada for producing monolithic microwave integrated circuits; to develop MMIC chip for application in a microwave landing system (MLS); and, to test MMIC in trial operation.

**Current Targets**

Understand the background of the project and the ongoing work.

Transfer the MMIC project responsibility from the Ottawa office of the R&D Directorate to TDC, Montreal.

Monitor ongoing R&D activities of Phase 2 - Chip Development.

Review plans and directives of future work.

Initiate discussions regarding an agreement for Phase 3 MLS Module Integration.

## 4.3 Speech Recognition & Synthesis (I 430)

To establish a Canadian capability in speech recognition and synthesis and to apply this technology toward improved efficiency of Transport Canada's operations.

**Current Target**

Implement Integrated Transportation Information System (ITIS), application project to Victoria, B.C.

## 4.4 Other New Technologies (I440)

To undertake development of other enabling technologies considered to have important potential benefits for transportation. These technologies include, but are not limited to, linear electric motors, advanced batteries and superconductivity.

**Current Targets**

Participate in the DCIEM project with CTF Systems to develop a 20-channel magnetoencephalography (MEG) system and test its effectiveness in measuring effects of stress.

Investigate superconductivity applications to transport.

Continue investigation into battery-battery hybrid systems.

Develop mobile platform using aluminum/air batteries.

Investigate thermal management of electric vehicles.

Enlist expert advice on battery and electric vehicle technology.